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TRUE STORIES OF GREAT AMERICANS

THOMAS ALVA EDISON

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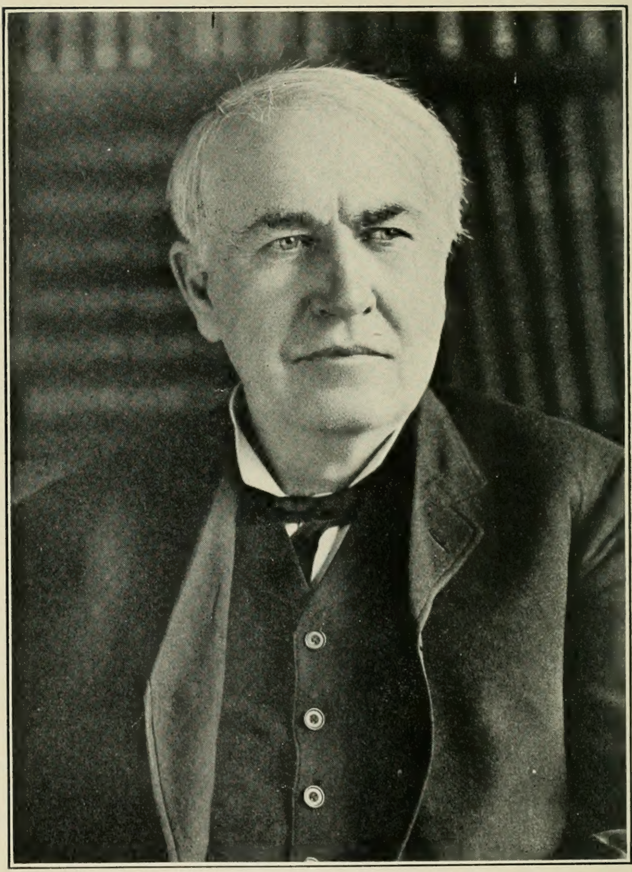

Thomas A Edison.

THOMAS ALVA EDISON

BY

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PREFACE

THERE is a great deal of satisfaction in writing a biography of a man who is not yet dead. Thomas Alva Edison is alive, very much so, and it is hoped that some measure of his vitality vibrates in these pages. To him, to his friends, and to former biographers — especially Messrs. Dyer & Martin, Francis A. Jones, W. K. L. & A. Dickson, and two anonymous writers — the author of this book acknowledges his indebtedness.

A personality such as that of Edison lends itself to many presentments. To use a simile, it is a gem on which many facets may be cut. This biography of "the Wizard," however, has one end in view — to show Edison as a Great American. That his life is a splendid stimulus to every American boy and girl, to every American man and woman, is the writer's belief, and to fling before the youth of the United States the heroic figure of America's greatest inventor in its most clarion appeal is the aim and purpose of

THE AUTHOR.

CONTENTS

LIST OF ILLUSTRATIONS

THOMAS ALVA EDISON

CHAPTER I

"Why Don't You Know?"

In every period of the world's history, there are men who become the great characters of the times in which they lived. Nearly always this is due to the fact that the talents they possessed, and the kind of work they did, was particularly well fitted to the great public needs of their time.

Thomas Alva Edison is the typical American. From boyhood to ripest manhood he has been keen to see an opportunity, and quick to turn that opportunity to a practical use. His genius is peculiar because it is so American. It is not as a scientist that Edison is great, it is not even as an inventor, it is as the master of the practical use of everything he touches that he appears a giant mind of modern times. When, in the summer of 1915, Edison was made Chairman of the Board of Civilian Inventors, as an aid to the

national defense of the United States in war as well as peace, it was America's tribute to a great American, rather than merely a progressive nation's recognition of an able inventor.

Not every boy can be an inventor, not every life can follow the type of work that has distinguished Edison, but every boy and girl can be as American. It is a mistake to think of "The Wizard of Menlo Park" — his nickname for many years — as though a list of his inventions told the story. Edison *and* his inventions is merely a record of a painstaking advance in science; Edison *through* his inventions is the story of a life of excitement and adventure.

It is not exaggeration to say that more wonderful feats have been done in Edison's laboratory than are told of the genie of the "Arabian Nights"; it is a modest statement to say that no giant was ever so powerful as the Giant of Electricity that Edison has fought to tame; and the stories of his quest in the farthest corners of the earth for threads of carbon for his lamp, or new kinds of wax for his phonograph records, cannot be surpassed by the narratives of any explorer.

Alone among the inventors of the world, Edison has always set before himself the ideal of making his inventions useful to the people. Speaking of

some interesting experiments that he had abandoned, on one occasion, Edison said:

"I could have worked it out all right, if I'd taken time enough, but what was the use? It wouldn't have been good for anything!"

Everything has contributed to make Edison a real American. His work is the expression of the man. He is not in the least European, neither in his way of thinking, nor in his methods of work. He is just good, plain, solid American. He can't help it, he was born that way.

Just exactly the same things that have brought the United States to the top among the nations of the world have made Edison what he is to-day. He is self-made and proud of it. He has built his career step by step. He has always had a huge desire for accomplishment and an enormous capacity for work. He knows how to organize — no one better — and not only can he use the skill of others, but he knows how to stimulate them to their best endeavor.

At the same time, the imaginative side of his work must not be forgotten, in looking at the practical results. It is in the times of nations when "old men dream dreams and young men see visions" that great things are born. Edison's gaze is always upward and forward. As child,

as boy, and as man, he has always held fast to the belief that "to-morrow is a new day."

Much of this determination to get ahead and of this directness in pressing toward the goal is inherited. In his forbears Edison was fortunate. Both his father and grandfather showed the same independence of thought and unflinching belief in their own opinions. When they thought they were right, they went ahead — and they usually thought themselves right. Sometimes events proved them to be wrong, but, undaunted, they started along a new line and went ahead still. Indeed, the United States owes the honor of counting Thomas A. Edison as one of her sons to the love of liberty which burned in the breast of his father.

Samuel Edison, the inventor's father, was thoroughly intolerant of injustice. Anything that he thought unjust, simply set him wild. There are half-a-dozen stories afloat which show how quickly he stepped forward when any question of principle was involved. In addition to this, Samuel Edison inherited from his grandfather a scrupulous sense of honor.

It is to be remembered that the inventor's great-grandfather — Thomas Edison — was a prominent bank officer and financier in New York during the

Revolutionary War. He was held in high regard as a standard of probity; so much so, that his is the only signature in the archives for authenticating the genuineness of the Continental currency.

Old Tom Edison was a hot Tory. In spite of that, after Independence had been established, and the "Original Thirteen Colonies" were colonies no longer, the New York financiers were anxious for him to continue under the new régime. Old Tom Edison refused. Carrying out his principles, he went to Canada, where the British government made him a gift of a large tract of land in recognition of his loyalty and his services.

The next rebellion in which the Edison family took a part was the Papineau rebellion. Samuel Edison was a strong believer in the rights of the people, and was with the "constitutionalists" as against the "royalists" in the union of Upper and Lower Canada. Indeed, he felt so strongly on this point that he scornfully refused to live any longer on land that had been given to his father by the crown, repudiated the gift with stern independence, and kept a hotel at Bayfield. When rebellion actually broke out in 1837, under the French-Canadian, Louis J. Papineau, Samuel Edison took arms, joined the insurgents, and rose to the command of Captain. The rebellion failed,

and Captain Edison, as one of the rebel leaders, was hunted for, with a price on his head.

The sturdy lover of liberty wasted no time, but made tracks for the St. Clair River. He did not dare show his face at any railroad stations and he feared that getting a horse might attract attention. Whereupon, being over six feet in height, and with a gaunt, muscular frame, he determined to walk to the Land of Freedom. Stopping only once for a three-hour sleep, Samuel Edison walked the hundred and eighty-two miles that lay between him and safety. These powers of endurance were a part of Samuel Edison's heritage to his gifted son.

A little incident which occurred at the time of the beginning of the Civil War shows the sturdiness of the Edison stock. When recruits were called for, Samuel Edison was sixty-five years of age, too old for service. But he was not too old to advise, and he took the greatest interest in the "boys" who were going to the front in the Union Army. One day it chanced that a friendly jumping contest was begun in a regiment of newly drafted recruits stationed at Fort Gratiot, Michigan; they were husky young fellows, most of them, but the old veteran of the Papineau Rebellion out-jumped them all. He lived to the ripe

age of ninety-seven years. Indeed, long life is hereditary in the Edison family, the inventor's grandfather having lived one hundred and three years, while his great-grandfather lived to be one hundred and two years of age.

Having decided to live in the United States, for Canada was far too hot to hold him, Samuel Edison finally settled down in Milan, Ohio, a small town where he thought there was little likelihood of his being traced by the Dominion authorities. Finding matters peaceful enough, he decided to let rebellions alone and to make his home there. A few years later he married a young Canadian school-teacher whom he had known prior to the Papineau outbreak, and brought her to his home in Milan.

It seems strange now, if one visits that sleepy little Ohio village, to realize that it was the birthplace of so vigorous and world-shaking a personality as Thomas A. Edison. It is, perhaps, even more difficult to realize that this dozing rural crossways was, at the time of Edison's birth, a busy commercial center.

The little town has had an eventful history. Seventy years ago, before the railroads had reached that part of the country, it became necessary to find an outlet for the great quantities of grain to

be shipped to eastern points from the vast wheat and corn fields of Central and Northern Ohio. The Huron River, emptying into Lake Erie, could only be navigated for a few miles above its mouth, and so a landing was made about three miles below the little village of Milan. A number of warehouses were built there, and Lockwood Landing showed every indication of becoming a prosperous market.

The people of Milan, however, were wide-awake and progressive, and a project was broached by some of the merchants to build a canal from Lockwood Landing to Milan. As this would bring navigation right to the village and carry prosperity with it, the plan was approved at once. In this progressive movement, Samuel Edison played a leading part. A great deal was thought of his judgment, and his personality was so forceful as easily to win others to his way of thinking. In his ability to enlist capital in the canal project is a foreshadowing of his son's extraordinary talents in securing financial backing for his operations.

When Thomas A. Edison was born, February 11, 1847, the little town had become a center of industrial activity, and the young lad's earliest recollections were those of a thriving market

town with a dozen big warehouses on the bank of the canal. All day long, wagonloads of wheat and other grain poured into the place, some drawn by horses, but more of them by the ox teams which at that time did most of the farm hauling of the west. Indeed, so well did the town thrive, and so important a factor did the canal become, that shipbuilding actually became a prominent industry, and several vessels, including six revenue cutters, were launched in the waters of the canal.

Where is that canal now? Not only is it no longer used, but, actually, it is not. It does not exist. Wander now through Milan, the small sleepy place, and you shall search in vain for the grain warehouses, you shall look in vain for the long lines of ox-drawn wagons, you shall listen in vain for the cracking of the whips and the "gee" and "haw" of the impatient drivers, you shall even look in vain for the canal. Perhaps, if you search diligently and secure the guidance of "the oldest inhabitant," he will point out to you a slight depression in the ground which may be traced for a few miles as the bed of the old channel, but that is all. Brief was the span of Milan's fame as a commercial center, but she has secured a far more enduring reputation as the birthplace of her great son, Thomas A. Edison.

Not that Milan was particularly conscious of the greatness of the boy. Far from it. Indeed, he was a particularly aggravating youngster in many regards. Every properly organized boy and girl asks questions — for that matter, any child who does not ask questions ought to have a dose of curiosity squirted into him some way, — but Edison was simply a terror! Just as soon as he was able to talk, he plunged into a steady stream of "Why?" to everything. Some of these queries his father could answer, a still larger proportion of them could be solved by his mother, but the youngster's mind was too fertile and his curiosity too overwhelming for any one to keep up with it to the end. Sooner or later, the grown-up who was the victim of this remorseless questioning would have to fall back on the stock answer:

"I don't know."

"Well," the determined child would reply, ruffling up his hair in the way that has been a characteristic ever since he could reach up to his hair to ruffle it, "why don't you know?"

Just as soon as he was able to toddle, the young lad found his way down to the shipbuilding yards. He got terribly in the way of the workmen, and it used to be said, laughingly, that whenever the boy came down, it saved time to have one of the

men detailed to answer his questions. In spite of this, however, 'Al' was well liked, and no matter how much he bothered them, there were always some men who were ready to give him the answers which he really wanted.

So persistent was the questioning, however, and so inquisitively particular were some of his queries, that the workmen used to think them foolish. He asked questions about their work which they themselves could not answer. What could be more absurd, they thought? Not a single man in all the yards ever grasped the fact that the small urchin's queries showed that he was thinking into causes, while they were satisfied merely to do the things that they had learned while in their apprenticeships.

An example showing how early the experimental desire displayed itself in Edison is the incident of the goose. Having pestered his mother with questions as to what goose eggs were, and what was in them, and where they came from, and how they were made, and if they were all made that way, and why the goose made them that way, and why they were all that shape, and what would happen if they were not that shape, and a hundred more such queries, he reached at last the question:

"Why does the goose squat on the eggs, Mother?"

"To keep them warm," was the reply.

"And why does she keep them warm?"

"To hatch them, dear."

"What's hatching?"

"That means that the little geese come out; they are born that way, you know."

"And does keeping the eggs warm make the little geese come?"

"Yes."

That was enough for Edison. He reasoned that he was bigger than the goose, therefore he had more warmth, therefore if he sat on the eggs the little geese would come quicker. He sat on them. The reasoning seemed sound, even if the results showed that it must have been fallacious. One thing is sure — that particular batch of eggs did not hatch out.

Grown-ups do not always follow the workings of a child's mind, and incidents such as his sitting on the goose's eggs led some of the neighbors to the conclusion that the boy was a softy. Even those who were most kindly disposed to him were inclined to take the view of his detractors when they themselves became the object of one of these bombardments of questions, always ending up

with the invariable evasion — "I don't know," and its terrible and pitiless query of rebuke — "Why don't you know?"

The "hired girl" of the Edison household, for many years one of the boy's sturdiest admirers, lost a great deal of her enthusiasm and was forced to adopt a policy of "watchful waiting" whenever the lad was around, by reason of one of his experiments upon her. He was not five years old at the time and he had settled it to his satisfaction that the only reason why birds could fly and human beings couldn't, was because they didn't eat the same things. So he worked up a weird concoction (in which worms figured largely) and insisted on the hired girl drinking some of it. She did. She didn't fly, but the boy's father did — for the nearest doctor.

The story is a childish one, of course, but after all is said and done, the principle is not greatly unlike one which was successfully followed in Edison's later years, one, indeed, which has added to the art of medicine a valuable treatment for gout.

"What's the trouble?" asked Edison of a friend one day, on meeting him in the street and noting the swellings of his finger joints.

"I don't know exactly —" the sufferer began, when Edison struck in with the eternal question.

"Why don't you know? Don't the doctors know?"

"They don't agree," the other replied. "But most of them seem to think it's gout."

"Well, what's gout?"

"Deposit of uric acid in the joints, I'm told," answered the sick man.

"Why don't they take it out of the joints, then?"

"They don't know how."

This was like a red rag to a bull.

"Why don't they know how?" stormed Edison, indignantly.

"Because uric acid is insoluble."

"I don't believe it," the world-famous experimenter replied.

On his return to his laboratory, he started immediately to find out whether it were true or not that uric acid was insoluble. He set out an array of test tubes — a couple of hundred of them, at least — and filled them all about a quarter full of every different chemical he possessed. Into each he dropped a few uric acid crystals. Two days later he found that the crystals had dissolved in two of the chemicals. The inventor was justified, experiment had again blazed the way, and now one of these very chemicals (hydrate

of tetra-ethyl ammonium) is widely used in the treatment of gout and other diseases.

Edison's "Why don't they know?" therefore, in this case has helped to ease the pain of thousands of people. As the history of his inventions unfolds itself, it will be seen how he made use of the ideas of others. Where they had stuck, where they had come to an "I don't know!" point, Edison put his persistent query and finally worked out an answer.

In Milan, no one was sufficiently foresighted to see in the boy's exploits the prophecy of the powers of the man. He would have been the last boy that the wiseacres would have picked out as destined to bring the greatest honor to the town. It often happens that way. No one is wise enough to tell all about the future flower by looking at the seed.

"I was always a careless boy," said Edison in one of his rare personal interviews, "and with a mother of different mental caliber I should probably have turned out badly. But her firmness, her sweetness, her goodness, were potent powers to keep me in the right path. I remember I used never to be able to get along at school. I don't know now what it was, but I was always at the foot of the class. I used to feel that the

teachers never sympathized with me and that my father thought that I was stupid, and at last I almost decided that I must really be a dunce. My mother was always kind, always sympathetic, and she never misunderstood or misjudged me. But I was afraid to tell her all my difficulties at school, for fear she too might lose her confidence in me.

"One day I overheard the teacher tell the inspector that I was 'addled' and it would not be worth while keeping me in school any longer. I was so hurt by this last straw that I burst out crying and went home and told my mother about it. Then I found out what a good thing a good mother is. She came out as my strong defender. Mother love was aroused, mother pride wounded to the quick. She brought me back to the school and angrily told the teacher that he didn't know what he was talking about, that I had more brains than he himself, and a lot more talk like that. In fact, she was the most enthusiastic champion a boy ever had, and I determined right then that I would be worthy of her and show her that her confidence was not misplaced."

Edison's active brain and his habit of taking the most direct road of testing everything he came across, got him into scrapes many a time

after this. Indeed, he would be likely to admit that it did, still. But Edison has possessed the faculty of finding friends who believe in him through thick and thin. Valuable and trusted friends though they have been, Edison to this day declares that his best backer was his mother.

CHAPTER II

The "Candy Butcher"

It is a good illustration of Edison's ability to make the most out of every opportunity that came his way, to see how he utilized for his own advancement the very force which caused the downfall of his native town.

After having dug the canal, the capitalists of Milan so highly esteemed their cleverness that when, a few years later, the Lake Shore railroad company approached them with regard to franchise and other arrangements for running the road to Milan, the citizens declared that they were content with their water transportation and would stand by that. As a result, the railroad was surveyed through Norwalk and Wakeman, and the trade of Milan first dwindled, then departed absolutely.

Before trade collapsed too far, Samuel Edison, who was "forehanded" and understood the value of being in the van of progress, decided to move. After careful investigation of conditions in the

neighboring towns, he decided to settle in Port Huron, Michigan, a place of considerable commercial activity. A roomy house, with a large apple and pear orchard, was purchased, quite in the country, yet within easy walking distance of the town.

The view was magnificent, so fine, indeed, that Samuel Edison built a rickety wooden tower about eighty feet high, commanding the St. Clair River and Lake Huron. The combined disadvantages of the insecurity of the structure and the ten cents fee rendered visitors to the observatory few and far between, but the boy spent a great deal of his spare time on the summit, and learned astronomy with the aid of an old telescope which was lent him by his father.

The education of the boy was left entirely in the hands of his mother. Her early training as a teacher stood her in good stead, and she conducted the morning lessons for her son with the same punctuality and rigid observance of rule which she had used in her classes in the public schools.

Thomas Alva, or "Al," as he was always called, was as satisfactory a private pupil as he had been an unsatisfactory one in a class with other boys. He was serious, of tremendous application, and had a marvelously retentive memory for things

which really interested him. If they did not — well, he wouldn't learn and he couldn't remember.

This remains one of Edison's greatest weaknesses. The gaps in his knowledge are as unexpected and surprising as is the extent of his information. Mathematics is his bane, and he has very little use for it. When he was building the first great central station for the electric lighting of New York, he was always in conflict over figures.

"In all that central station work," he said, many years after, "the great bugbears I had to contend with were the mathematicians. I found, after a while, that I could guess a good deal closer than they could figure, so I went on guessing."

Some one asked him how it was that his dynamos generally came up to the required power when they were built by "guesswork," and he replied, with a smile,

"Well, I happened to be a pretty good guesser!"

Then, in order to show how mathematics may prove more difficult and troublesome than "guesswork," the inventor told the story how he had beaten the mathematicians at their own game. When he perfected the ordinary pear-shaped glass bulb for incandescent electric lights, he wanted to find out the exact cubic contents. He gave the

problem to several eminent mathematicians and they figured it out. Their answers all differed, though only slightly.

"You're all wrong," said Edison, "and I'll show you."

He had made a series of tin cubes, each one a trifle smaller than the other. He filled a bulb with water and poured it first into one cube, then another, until he found the one that held exactly the same quantity of water as the bulb. Figuring the cubic contents of a cube, of course, was easy.

This is only one side of the story. The other is the evidence that Edison is just as much forced to depend on mathematics as any other man, only — he has some one else do it for him. When he was on the witness stand, describing some experiments that he had made for the State of New York with regard to electrocution, he stated that the temperature of a tube of water the height of a man would rise eight degrees Centigrade under the application of a certain current of electricity. The lawyer, in cross-examination, asked the inventor how many degrees that meant on the Fahrenheit scale.

"I don't know," Edison replied.

"You don't know!" exclaimed the lawyer in surprise. "Well, surely you could compute it for us?"

"I don't compute such things," was the reply.

"How do you find out, then?" queried the lawyer, sharply.

"I ask somebody."

"Whom do you ask?"

"Oh, I have men to do such things," the inventor answered, stifling a yawn. And, on request, he called on A. E. Kennelly, afterwards President of the Institute of Electrical Engineers, who was his head mathematician at the time.

The incident is worth remembering, for it shows clearly that unless Edison had possessed the money to employ Mr. Kennelly, his work would have suffered from his lack of knowledge of mathematics. No boy can say to himself, "Edison isn't a mathematician, I don't need to be." Ignorance of any subject is never a matter for boast.

It was this very ability to do some things and apparent inability to do others that crippled Edison in school. Under any less unusual circumstances than the home tuition plan, it would have crippled him seriously. But, being allowed to go his own way to a certain extent, he sprang ahead in his studies like a prairie fire in the autumn after a dry spell. At the age of nine he had read, and read thoroughly, half a dozen of the big histories, such as Hume's "England," and Gibbon's

"Rome"; and he had painfully endeavored to digest and remember the whole of the "Penny Encyclopædia." Also, he had managed to secure a number of works on scientific subjects, and before he was ten years old, was conversant with practically everything that had been done in electricity up to that time.

The first three years of the boy's life in Port Huron were given over almost exclusively to reading. He tried to read the Public Library through from beginning to end, until the librarian, noticing the lad's lack of systematic choice in his subjects, gave him some practical advice. During this period he kept up with almost every electrical discovery being made. Edison was fortunate in the time of his birth, for his aptitude and genius for things electrical came at the same time as the development of that science.

In spite of the interest of the subject itself, however, there is more than a shrewd suspicion that Edison's intense interest in electricity was partly due to the fact that every one answered, "I don't know," when he tried to find out what electricity really was, and he set himself to discover "why they don't know."

When about eleven years old, young "Al" Edison determined to try and help in meeting the

family expenses. Practical as always, the boy was more interested in results than in means, and cared less about the character of the work than about the profits. Naturally, his mind ran to selling papers, since that is the first avenue for a boy. But, with that judgment of practical issues which has ever since been so large a factor in Edison's development, before beginning work he figured up how much money he would make in proportion to the amount of time spent. He decided that selling news-sheets through the streets did not bring profit enough. Entirely on his own account, he applied to the Grand Trunk Railroad for the privilege of selling newspapers, books, magazines, fruits and candies on the trains between Port Huron and Detroit.

"Everything comes to him who, hustling, waits," said Edison once, and this adage applied to his boyhood. While his application was on file, he turned to the selling of papers in the streets. He found, as he had expected, that the few nickels he gained were a poor compensation for the amount of work involved. He was more successful than the other boys, however, owing to the fact that he read the papers carefully during the pauses between the selling of his wares, and accordingly often was able to catch the attention of a possible

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EDISON AS A "CANDY BUTCHER"

customer by his references to the topics of the day, while the other "newsies" were content with the stereotyped cry of "P-i-per, Ev-en-in' pi-per!" At last his application was granted, and the boy began his duties as a trainboy or "candy butcher," in the slang of that time.

The day was a long and hard one. Young Edison had to be aboard the train a little after 6.30 A.M. to arrange his wares before the train started, which was at 7 o'clock. Detroit was reached at 10 A.M., and the remainder of the morning and the afternoon was spent in buying goods to sell on the train. Though extremely quiet and always preoccupied, the boy had the faculty of causing people to like him. His self-confidence and boyish dignity always won respect.

As a consequence he became very well known in Detroit, and the fruit vendors, the stationery stores and the candy shops regarded him as a favored customer. He was always keen to take advantage of sales, also, and many a small item found its way into his stock to be sold at a fair advance on the investment. The return trip was begun at 4.30 P.M. and it was seldom earlier than 8 o'clock when the train reached Port Huron, and verging to 9 o'clock in the evening when the boy reached home for supper.

Young Edison had a good business head, and within a year of his first entering the railroad work, he had two assistants, as well as the privilege on another train. His profits were from $12 to $20 a day.

These were the times of the Civil War. Newspapers were not merely read with interest, they were snatched at with eagerness. Most boys would have been well satisfied with the demand that existed. Not so "Al" Edison. He saw no reason why he could not sell twice, three times as many more. Selling papers was his business. Very well. He would raise that business to the highest point of efficiency.

He made friends with one of the compositors on the *Detroit Free Press* and used this acquaintanceship to such good effect that he gained access to the proofs. By reading these, he was able to know nearly every item in the paper before it was printed, a fact which aided him greatly in selling his papers. On the train he had no more time than was necessary to sell them.

Several times the keen lad noticed that when there was war news of an especially interesting character, his papers would sell like hot cakes, and unless he were careful, there would be none left for his regular customers at the end of the trip. This set

him thinking, and in a business deal that he himself has never rivaled since, he determined upon a plan.

A few days later occurred the great two days' battle of Shiloh, won by the Union Army, but in which the loss of life by both armies was very severe. His friend in the *Detroit Free Press* office showed him a proof containing the news. The boy, who had been following the campaign closely, saw the strategic value of this victory and also saw its news value. He perceived that the time had come.

Hurrying to the station, he ran as fast as he could to the telegraph office, and told the operator, who was his friend, all about the battle. Then he continued, making the following offer:

"If you will wire to each of the principal stations on the road, where that train stops, and ask the station master to chalk on the black bulletin board — used for showing time of arriving and departing trains — the news of the battle and the number of lives lost, I'll give you *Harper's Weekly*, *Harper's Monthly* and a daily, free, for six months."

The operator agreed at once to the proposal.

Back to the office of the *Free Press* went Edison.

"Please, I want a thousand papers instead of three hundred," he said to the delivery clerk, "and I'll pay you to-morrow."

The clerk, who was not permitted to sell papers on trust, refused him.

Feeling desperate, and determined not to lose the opportunity that had been made by the telegraph operator's willingness, the boy decided on a bold stroke. He went to the editorial rooms and asked to see the editor. At first he was refused admittance, but his manner was so positive and his statement that his business was important seemed so assured, that he was admitted to an office where two men were talking.

No sooner had he stated in short, crisp sentences what he had done, and how he had opened a new avenue for the extended sale of the paper, than one of the men, with a short laugh, leaned forward, wrote a few words on a scrap of paper and handed it to Edison. This was Wilbur F. Storey, afterwards founder of the Chicago *Times*.

"Take this down," he said. "I wish you luck. Hope you come out on the right end."

Edison thanked him, got his thousand papers, hired another boy to help him carry the pile to the train, and, as it pulled out, set to work folding them. The remainder of the story may be told

in Edison's own words, quoted mainly from Dickson's "Life of Edison."

"At Utica, the first station out from Detroit, and about twelve miles distant, I usually sold two papers, our customary charge being five cents each. As we approached the station on this day, I put my head out to look forward, and thought I saw an excursion party. I had half a dozen papers in my hand. As we came nearer, and the people caught sight of me, they commenced to gesticulate and shout, and it suddenly occurred to me that they wanted papers. I rushed back into the car, grabbed an armful, and when I got upon the platform, I sold forty.

"Mount Clemens was the next station. When it came in sight, I thought there was a riot. The platform was crowded with a howling mob, and when the tones became intelligible, I realized that they were after news of Pittsburg Landing (Battle of Shiloh), so I raised the price of papers to ten cents and sold a hundred and fifty where I had never before disposed of more than a dozen.

"As other stations were reached, these scenes were repeated, but the climax came when we got to Port Huron. There the town is quite a long ways from the station, so it had been my habit to jump from the train about a quarter of a mile

from the depot. I'd paid a little Dutch kid to haul several loads of sand to that point, and the engineers always knew I was going to jump and slowed down a bit. Still, I was quite an expert. I heaved off my bundle of papers and jumped. Shouldering the bundle I started for the city, as usual being met by the Dutch boy.

"We'd hardly got half way to the town when I met a crowd hurrying toward the station. I thought I knew what they were after, so I stopped in front of a church, where a prayer-meeting was just closing, raised the price to twenty-five cents a copy and commenced to take in a young fortune. Almost at the same moment the prayer-meeting came to an end, the members came rushing out, and if the way coin was produced is any indication, the deacons must have forgotten to pass the plate at that meeting."

Edison's biggest haul, however, was one day when he encountered a group of young Southerners who had come up North on some special business, but were having no end of a lark at the same time. Young Edison was carrying his basket of nuts and apples through the car. Luck had been bad so far, he hadn't made a single sale in the smoking car, and even in the general car — which used to be called the "ladies' car" — the first few seats had

been profitless. As the boy came down to the seat where these young chaps were sitting, one of them suddenly grabbed the basket and threw the contents out of the window.

For a moment the boy was too surprised to speak, then the Southerner politely handed back the basket, and speaking over his shoulder said to an aged negro sitting behind, evidently an old slave,

"Nicodemus, give this young gentleman a dollah!"

The darky grinned, and unlocking a large iron-bound box which was before him on the seat, full of money and valuables, took out a dollar and gave it to the boy. Distinctly surprised and not understanding the matter at all, young Edison grabbed the dollar and hurried away with the empty basket. After all, he had made a good profit on the basketful of fruit. Quickly he filled up his basket again and started down the aisles of the train. This time he piled his basket with prize packages. Only one purchase was made. Presently he reached the point in the train where the Southerners were sitting. He stopped and was about to speak when one of them said,

"Excuse me, suh," grabbed the basket again and sent the prize packages out of the window in

the same way that the peanuts and apples had gone. Everybody laughed except the Southerners, who never cracked a smile through the whole performance. This time Edison said,

"Look here, Mister, do you know how much those were worth?"

"No, suh," he answered, "how much?"

"There were just forty," the train-boy replied, "except for one that I sold in the smoking car."

"Nicodemus," said the other, "count out the money for the boy."

Again Edison trudged away with the empty basket and the filled pocketbook. He hustled back as quickly as he could with the morning papers. The passengers had caught the spirit of the thing and they laughed in anticipation as soon as the boy came in the car. It didn't cost them anything, and the sport certainly relieved the tedium of the journey. Naturally, none of them bought any papers.

As soon as the boy came within reach of the Southerners, one of the party, a different chap this time, yanked the bundle from the lad's arm and threw them out of the window after the other things. This time Edison laughed.

"Settle with Nicodemus," the Southerner commented in an offhand manner, and Nicodemus

handed out the necessary money with the gravity of a judge.

Then Edison decided to get into the game himself. He went into the baggage car and hunted up every paper available, over a hundred of them being returns from the day before, which he was going to turn in at the end of the day's trip. It made a huge pile, almost all that the boy could do to stagger under. When he reached the door of the car and shouted "Pi-per" in the accepted manner, the passengers guffawed in expectation. The Southerners didn't like to back down, because they knew every one in the car was watching them and they were trying to show off. So they didn't hesitate a second, but just hefted the entire lot between them and spread them over the landscape.

"Look yah, suh," said the elder of the party, as soon as Nicodemus had arranged the necessary financial end of the situation, "have yo' anything else on board?"

"Nothing except my basket and my box," the lad replied.

"Well, bring those, too."

The box was too big for Edison to carry, but he "up-ended" it and dragged it down the aisle of the car to where the three young bloods sat. The

basket followed the same route as the other things, and Nicodemus chucked the box off the rear platform.

"Have you nothing mo' to sell?" one of them then asked.

"I would have brought in the smoking car stove, if it hadn't been alight," Edison was used to quote himself when telling this story, "but I had to say that there really was nothing more."

"Well, then," said the other, "Nicodemus, yo' can throw this boy out of the window."

There was a howl of laughter from the other passengers, and as Nicodemus got up with the evident intention of carrying out his master's orders to the letter, Edison got out of that car as quickly as he ever did anything in his life.

CHAPTER III

THE SAD END OF *PAUL PRY*

THE occupation of a "candy butcher," however profitable, could not be expected to engage more than a small share of so active a mind as that of young Edison. The "mixed" train, on which his work lay, consisted of a baggage car, a smoking car and a general car. The baggage car was divided into three compartments — one for baggage, one for United States Mail, and one for express matter. This last section was never used, and it was in this that the lad kept his supplies.

One of the stores from which the boy bought a large part of his wares was kept by J. A. Roys, who carried books, magazines, stationery and notions. It was largely owing to a chance purchase of a printing-press that Edison branched into the next period of his career, that of editor and newspaper proprietor.

"I sold Edison that famous printing-press," Mr. Roys is quoted by F. A. Jones as having said, "and I have sometimes wondered what became of

it. I got it from the tenant of a house I owned, who couldn't pay his rent. To reimburse me, he turned over the printing-press.

"Young Edison, who was a good boy and a favorite of mine, bought goods of me and had the run of the store. He saw the press, and I suppose the idea of publishing a paper of his own immediately occurred to him, for he would catch on to anything new like lightning. He examined the machine, got me to show him exactly how it worked, and finally bought it from me for a small sum.

"Afterwards I saw many copies of the paper he printed, and for several years kept some as curiosities, but they got torn up or lost, and now I don't believe there is one to be had unless he owns it himself. [This was a shrewd guess, for Edison does own the only known copy in existence.] He was a smart youngster and I always prophesied great things of him."

As the same baggage car was always on the train, Edison moved his printing-press into it. Through his friends on the *Detroit Free Press*, for a very small sum he bought a lot of old type, much of which had been "pied," and a few battered "stock" cuts were thrown in, for good measure. He had learned to set type, and two weeks after

the purchase of the printing-press, appeared the first copy of *The Weekly Herald*, written, set up, printed, published and sold by the fourteen-year-old boy.

The Weekly Herald was a local paper and claimed to be nothing else, and, as was natural in the only paper in the world up to that time printed and published on a moving train, railroad matters claimed a good share of the editor's attention. The boy side of Edison, however, appears in his biggest "news item," which, headed "DIDN'T SUCCEED," ran in exactly the following manner:

"A Gentleman by the name of Watkins, agent for the Hayitan government, recently tried to swindle the Grand Trunk Railway company of sixty-seven dollars the price of a valise he claimed to have lost at Sarnia, and he was well night successful in the undertaking.

"But, by the indominatable perseverance and energy of Mr. W. Smith, detective of the company, the case was cleared up in a very different style. It seems that the would be gentleman while crossing the river on the ferry boat, took the check off of his valise, and carried the valise in his hand, not forgetting to put the check in his pocket, the baggageman missed the baggage after leaving Port Huron, while looking over his book to see if he had every thing with him, but to his great surprise found he had lost one piece, he telegraphed back stateing so, but no baggage could be found. It was therefore given into the hands of Mr. Smith, to look after, in the meantime Mr. Watkins

wrote a letter to Mr. Tubman Agent at Detroit, asking to be satisfied for the loss he had sustained in consequence, and referring Mr. Tubman to Mr. A. W. Howard, Esq., of Detroit, and the Hon. Messrs. Brown and Wilson of Toronto for reference. We hardly know how such men are taken in with such traveling villians, but such is the case, meantime Mr. Smith, cleared up the whole mystery by finding the lost valice in his possession and the Haytian agent offered to pay ten dollars for the trouble he had put the company to, and to have the matter hushed up,

"Not so, we feel that the villian should have his name posted up in the various R.R. in the country, and then he will be able to travel in his true colors."

The same indignation against an unjust claim which made his father stand out against injustice, forty-five years before, shows clearly in this article. It shows, too, that understanding of the value of personalities which is one of Edison's great charms. The inventor is very human and a very good friend.

The Weekly Herald was a great success. Its biggest "sworn circulation" was about seven hundred copies, of which nearly five hundred were subscriptions. The paper attracted the attention of the famous English engineer, Robert Stephenson, who ordered a thousand copies for himself, for distribution in railway circles all over the world. Even the London *Times*, the real old "Thunderer" as it was in those days, famous in both hemispheres

as the stiffest and most conservative journal ever known, unbent sufficiently to notice the little paper and even quoted from its columns. Financially, also, it was a success, and netted its fourteen-year-old proprietor an income of about forty-five dollars a month.

With his work as train-boy and his weekly paper, one would have imagined Edison's energies to be fully occupied. This was not the case. As soon as the novelty of getting out the *Herald* began to pall, and it became a matter partly of drudgery, the lad's eager brain sought a new object of interest. This he found in chemistry and in electricity. The success of his ventures in telegraphing war news ahead had made Edison acquainted with the possibilities of the telegraph, and one of his firm ambitions was to become a telegraph operator. But as of old, his interest was stimulated by the mystery of electricity. To every deadlock came his invariable query, "Why don't they know?"

Always eager to find out for himself, young Edison added to his little workshop in the express section of the baggage car, self-made telegraph instruments of a crude sort, batteries and chemicals. Little by little the collection grew, until it became a jumble of things. The conductor of the train, a clean-cut, duty-loving Scotchman,

named Alexander Stevenson, had never been favorably disposed to the transformation of part of the baggage car into a combined printing-shop and laboratory.

Although he did not approve of it, Conductor Stevenson was fair. As long as the train-boy did his work, and his printing-press and chemicals did not interfere with the running of the train, he was willing enough to give the lad a chance to educate himself. The conductor belonged to the old school, and, besides, had a temper as quick as his Scotch accent was strong.

One unhappy day, when the train was running over a rough bit of road, a phosphorus bottle, which had been jolted from its place, fell to the floor and broke, bursting into flame as it did so. The woodwork caught fire and the floor began to blaze.

The conductor wasted no time. Without a word, he snatched at the fire buckets, and by prompt work, put out the fire in a few minutes. While the blaze lasted, the matter was too serious for speech, but the instant that the danger was over, the peppery Scotchman turned on the boy, cuffed him on the side of the head, and soundly berated him for imperiling the lives of passengers on his train.

As the engine was then slowing up at Mt. Clemens, the conductor emphasized his remarks by throwing out on the platform all the boy's belongings, including the printing-press, which he toppled out as though it were a trunk, breaking it to pieces. Chemicals, batteries, instruments — everything went into the same heap. Only the basket of supplies, which belonged to the official work of "candy butcher," remained. Dazed, as much by sorrow over the destruction of his cherished laboratory as by the box on the ears he had received, young Edison stood on the platform at Mt. Clemens and watched his scientific home disappearing in the distance.

A great deal has been written about this incident, and the conductor has been sharply criticized, especially as there is more than a suspicion that the great inventor's deafness was caused by this box on the ear, but it is difficult to see that Stevenson could have done anything else than he did. He was the conductor in charge of the train and the safety of passengers was his first consideration; when he found that a boy of fourteen was endangering a train for which he was responsible, he could do nothing less than remove the danger. One may sympathize with young Edison, "standing forlornly among the ruins of his most cherished

possessions," but the inventor was in the wrong. The baggage car of a moving train is not the place for explosive or inflammable chemicals, and his punishment was, as he has since admitted, "coming to him."

No grudge appears to have been borne by either Edison or the conductor. The boy resumed his work as "candy butcher" on the train next day, and no mention was made of the incident. The conductor felt that he had done his duty and he forbore to "rub it in." Edison felt that Stevenson could at least have waited until the train reached Port Huron and given him a chance to take away his belongings without damage, but he had too much pride to ask for any renewal of the baggage car privilege.

Going to his father, "Al" made a clean breast of the whole affair, and begged for the use of a small unused room near the roof of the house as a workshop. The evidence that fire was to be feared made his father refuse him, but the boy compromised by promising not to store anything inflammable. So Edison fitted up another small workshop, where he continued to print *The Weekly Herald* and to make experiments.

Mt. Clemens was destined to be a second turning point in the boy's fortunes. The station agent,

Mr. J. U. Mackenzie, had witnessed the ignominious expulsion from the baggage car and his sympathies had been with the boy. This had increased the friendship between the two, when the event happened which made Mackenzie the boy's sworn ally. The account of this event which seems to fit in best with the known facts is the one given by Mr. Mackenzie himself, and quoted by W. K. L. Dickson.

"Edison, or 'Al,' as he was then called," said Mr. Mackenzie, "was at this time the newsboy of the mixed train, running from Port Huron to Detroit, and returning daily, Sundays excepted. He was at this period well on the road to success, and made it a point to leave at least one dollar of each day's earnings with his mother before starting on the following morning. Al had endeared himself to the station agents, operators and their families all along the line. As the mixed train did the way freight work and the shunting at Mt. Clemens, it usually consumed not less than thirty minutes in doing it, during which time Al secured new patrons for his wares, or played with my little two-and-a-half year old boy, Jimmy, of whom he seemed very fond.

"It was at 9:30 on a lovely summer morning. The mixed train had arrived, leaving its passenger

and baggage car standing on the main track at the north end of the station platform, the pin having been pulled between the baggage and first box car. The train, of some twelve or fifteen freight cars, had pulled ahead and had backed in upon the freight house siding, had then taken out a box car (containing ten tons of handle material for Jackson State Prison), and had pushed it with sufficient momentum to reach the baggage car without a brakeman controlling it.

"Al, happening to turn at this moment, noticed little Jimmy on the main track, throwing pebbles over his head in the sunshine, utterly unconscious of the danger he was in. Al dashed his papers and his cap on the platform and plunged to the rescue, risking his own life to save his little friend, and throwing the child and himself out of the way of the approaching box car. They both landed face down in sharp, fresh gravel ballast with such force that, when rescued, their appearance was somewhat alarming. Examination, however, proved the injuries to be only skin deep.

"Tommy Sutherland, the train baggageman, who was an eyewitness, told me that had Al been a second later he would have lost a foot or been killed, as the wheel of the car struck the heel of his boot. I was in the ticket office, and hearing

a shriek, ran out, in time to see the train hands carrying the two boys to the platform."

The next time they met, which was a couple of days later, Mackenzie, who was not rich and who had been racking his brains to try and think of some way in which he could show his gratitude, offered to teach the boy telegraphy. Edison jumped at the chance, and twice a day, when the train stopped at Mt. Clemens and was detained there, the lad practised Morse with his friend Mackenzie. A few times, Sutherland, the baggage man, offered to bring the evening papers as far as Mt. Clemens, and then Al was able to give almost the whole day to telegraphy, leaving the train on its up-trip at 9.30 and boarding it again on the down-trip in the evening.

At the end of a couple of weeks, Edison deserted his instructor for several days, going through to Detroit. On his return, he displayed a set of telegraph instruments he had made with his own hands in the gun shop of Fisher & Long. In his own characteristic way, he had gone into the shop and asked if he might have the use of a bench and tools for a few days, his friend J. A. Roys vouching for him, and telling the gun shop proprietor the story of the printing-press.

This early period of Edison's life is a wonderful tribute to the willingness of people to help. If a

boy is in dead earnest and can convince others that he is worth while, he will find thousands ready to help him. The half-hearted desire gets nowhere. Thousands of "newsies" might want to sell more papers, but it took an Edison to induce an editor to give him a thousand copies on trust, and to show that he had reason to suppose he could dispose of them. Lots of boys have set type for fun, but Edison was the first — and almost the only — person to print a regular weekly newspaper on a moving train. Any number of lads might like the privilege of using a gunsmith's bench and tools, but it was the definiteness of purpose in Edison that got him what he wanted. But whether it be the Grand Trunk and the earnest application for the "candy butcher" job, Storey and the thousand papers, Roys and the printing-press, the compositors and the proofs, the gunsmith and the bench, or Mackenzie and the telegraph key, the one fact stands out that the right sort of boy can generally get the help he needs, if he needs it badly enough and goes after it hard.

The change of the publication offices of the *Weekly Herald* from the baggage car to the lad's workshop in the home resulted disastrously. As young Edison was so little at home, he found it almost impossible to get the paper set up, and he

entered into an arrangement with the "printer's devil" of the *Port Huron Commercial* that he should set up the matter that Edison brought him, run off the paper and take a certain share of the profits.

The plan was working well but the new partner, not knowing anything about the railroad end of things, constantly disagreed with Edison about the items. Also, being even younger, and lacking the balance of the real editor, he was anxious for personal items of a funnier kind. He persuaded young Edison that a sheet of this kind could have a large local sale, as well as hold the subscribers already listed, and the *Weekly Herald* gave place to *Paul Pry*.

The few remaining numbers of *Paul Pry* show that the influence of the new partner was a great gain to Edison, so far as printing was concerned. The paper was more interestingly written, also. This was the pitfall into which it fell. Like many other would-be great writers, the editors of *Paul Pry* tried to be funny. But — as the keeper of an isolated lighthouse once pathetically remarked of his partner — "a funny man needs lots of room!" You can't be funny in a local paper, for some one is going to be hurt.

After the little journal had been running for a few weeks, an indignant subscriber appeared at

the office and asked for the editor-in-chief. He had been lampooned in the *Paul Pry* and wanted satisfaction. As he was about six feet high, and broad in proportion, Edison's boy partner was glad to be able to say that the editor was out. Unfortunately, subscriber and editor chanced to meet, an hour later, close to the St. Clair River. Whereupon the subscriber took the editor by his collar and his waist and heaved him, neck and crop, into the water. Edison swam to shore, and, wet, but otherwise undisturbed, discontinued the publication of *Paul Pry* and bade good-by to journalism forever.

Although Edison has at various times suffered at the hands of newspaper men, he has a very high regard for the American press as a whole.

"Looking over the whole country," he is quoted by F. A. Jones as saying, "I have come to the conclusion that the greatest factor in our progress has been the newspaper press. When one wants to do a thing the newspapers take it up. Everybody reads the newspapers, everybody knows the situation, and we all act together."

On another occasion he said:

"To let the world know through type who and what and where you are, and what you have that this great world wants, is the secret of success, and

the printing-press is its mightiest machine to that end."

Time, as has so often been said, has its curious revenges. The editor of the *Paul Pry* has often been repaid in kind by humorous stories about himself that have been annoying. One of the most amusing of these, and one which must have given huge joy to the angry subscriber of the little Port Huron sheet if he lived long enough to see it, was the fake story of the patent shirt, first published about the time of the success of the phonograph.

"I laugh at the story now," said the inventor, once, talking about it, "but at the time I didn't think it so amusing. One of the 'boys' [newspaper men] came down here one day, and not being able to see me or to get any startling information from any of my associates, he went home, probably feeling somewhat aggrieved, and wrote up a story of his own invention.

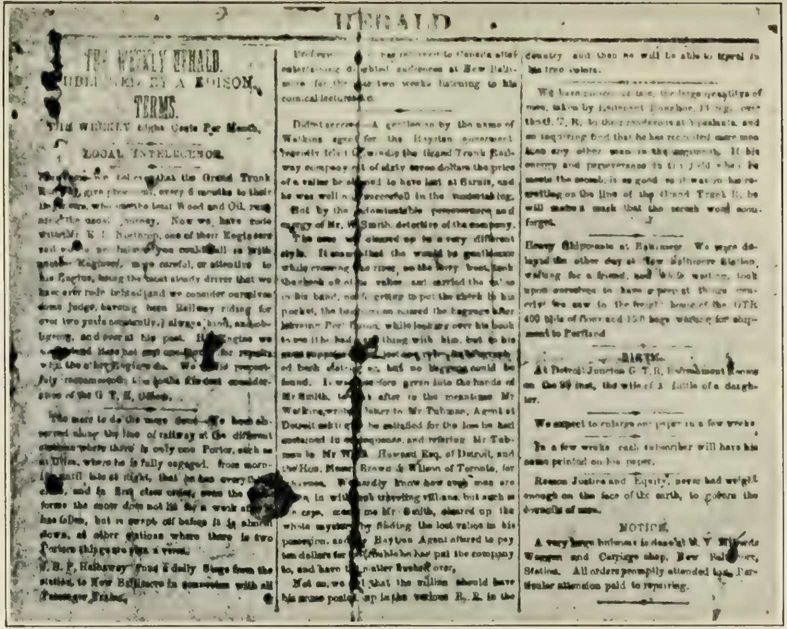
"He declared, in a very lucid and descriptive way — I've got to admit that the story was well written — that I was shortly bringing out a new and very ingenious shirt which would last the ordinary man twelve months, or longer, if he were economical. The front of the shirt, he declared, was made up of 365 excessively thin layers of a fibrous material — supposed only to be known to

me and one other of my associates. All that the wearer had to do when he put the garment on, each morning, was to tear off one of the layers, when the front would shine forth in all its pristine spotlessness and he would practically have a new shirt. Oh, it was a good yarn!

"The writer went on to say that I wore one of these shirts myself and that I considered the invention the biggest thing I had yet accomplished.

"Well, it seemed to be too good a story to let go. It was copied into a couple of hundred papers in the States, and from there went broadcast all over the world. Every race of people, from Chinamen to South Africans, seemed desirous of getting these shirts. Letters began to pour in, many of them containing drafts and checks. All these had to be returned. At first I gave orders that a polite form of reply should be sent. But we were getting swamped, and I wouldn't spend thousands of dollars on postage. Then agents began to pester us.

"I guess for more than a year these orders for 'Edison Patent Shirts' poured in, until at last the public began to realize that it had been hoaxed, and turned its attention to something else. But if I could have got hold of the young man who wrote it up, I guess he wouldn't have wanted a shirt or anything else on his back for several weeks!"



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NEWSPAPER PRINTED ON A MOVING TRAIN.

The Weekly Herald, managed, edited, written, set up, and sold by Thomas A. Edison, when only fourteen years old, the first paper of its kind in the world.

CHAPTER IV

The Crack "Lightning-Slinger"

"Dot; dash, dot, dot; dot, dot; dot, dot, dot; dot, (space), dot; dash, dot."

After all the years, this combination of telegraphic symbols spells to the old-time operator the name of one of the most famous men that ever clicked Morse over a key. Young Edison, seizing the advantage that had been given him by his friend the station agent at Mt. Clemens, soon became sufficiently expert to feel that he could fill a night operator's place. He had friends all along the line, and when the post of night operator became vacant in Port Huron, his home town, young Edison had little difficulty in securing the place, at a salary of twenty-five dollars a month.

So far as money was concerned, this was a distinct drop for "Al" Edison, but he felt that in it there was more opportunity than in his work as "candy butcher." His father, also, was doing well, so that his earnings were not needed by the family. As night operator, his duties were very

light, merely to record the passing of trains. Accordingly, Edison spent all day in his workshop at home, experimenting on things telegraphic and chemical. He could not be persuaded to sleep in the daytime, and consequently, when he came on duty, was always heavy and drowsy. The result was that the work was thoroughly unsatisfactory, and he would have been dismissed a dozen times over if the train dispatcher had not known him for years and liked him well.

After one particularly bad example of neglect, Edison got into such a pickle that he realized his job depended upon more care. He bought an alarm clock with a rattle like the roll of musketry, and a tin pan, set the clock for two minutes before the time of the arrival of the next train, put the clock on the upturned tin pan and went to sleep. When the alarm woke him — it would almost have wakened a deaf mute! — he sent his message, set his clock for the next train and went to sleep again.

This worked well for a few nights, for the trains were usually on time, but a couple of weeks later one of the trains was late and set back the whole schedule. Edison, who happened to be particularly sleepy that night, paid no attention to the train, but as soon as the alarm roused him, he reported

that the train had passed and went to sleep again. At the usual time for the next train he did the same thing, and so on through the whole night.

Then a storm broke! The train dispatcher sent for him and pointed out the danger to life that was caused by his neglect. He showed the boy the heinousness of sleeping while on duty. Then — and here was his mistake — instead of putting the boy on honor, he made it imperative for him to signal the letter 'A', or "dot, dash" every half hour. Edison was entirely satisfied with the plan, and being eager to keep his position, agreed to send the message regularly.

The very next night the plan was instituted, and, so far as the dispatcher was concerned, it worked admirably, for it was impossible for Edison to get a satisfactory nap in the intervals. The boy was less satisfied, for he could see that he would have to give up his experimenting during the day or else lose his job. When he reported for duty the next evening, his face wore that expression of satisfied innocence which an office boy carries when on his way to the baseball diamond to attend — "his grandmother's funeral."

As soon as the office was clear and Edison was alone, he opened a small box which he had brought down to the station and took out some coils of

wire, a couple of wooden pegs, and a few tools. He busied himself for an hour or so, connected to the sending-key of the telegraph and to the clock the small instrument he had made, and then leaned back in his chair to watch the outcome when the half-hour was reached. At the half-hour, exactly, a little wooden lever fell, sending an exact imitation of the Morse "dot, dash" and immediately afterwards another lever fell and closed the circuit.

Edison's smile grew broader, but he waited for the next half-hour cycle. When, at that time, the little instrument again performed its duties successfully, his smile broadened until it couldn't get any broader, and, so smiling, he fell asleep and slept the sleep of the ingenious, if not of the just.

So exact was this mechanical watcher that Edison's reputation was being reëstablished and the train dispatcher took great credit to himself for having designed a plan which was teaching the young operator the value of punctuality and attention to detail. Even the ingenuity of an Edison, however, cannot forever take the place of attention to duty. It happened that one night, while the dispatcher was making his rounds, he found himself only one station away from Port Huron, and after getting the usual signal from Edison, it occurred to him to call up the operator

and have a chat. He threw open the key and called. There was no reply. For ten minutes he called the station, at first expectantly, then angrily, and at last with alarm, for he began to feel sure that something dreadful must have happened. At last he gave up the key, and boarding a hand-car, he started off for the next station as hard as he could pump.

On reaching Port Huron he hurried across the platform and glanced fearfully through the office window, half-expecting to find Edison unconscious on the floor. Instead, a peaceful scene met his eyes. The telegraph operator, entirely unconscious of scrutiny, was lying across two chairs with a pillow and a coverlet and all the evidences of a regular sleeping arrangement. The train dispatcher was about to burst into the room when it occurred to him to wait and see what new scheme the boy had invented for being wakened at the half-hour interval.

But when the hands of the clock pointed to the required hour, Edison continued to sleep as peacefully as before and the alarm clock made no sound. Puzzled beyond words, the dispatcher watched for a moment or two longer; then, in a way that seemed like magic, a lever operated by a small instrument on the table opened the circuit, the

instrument "got busy" and sent the required "dot, dash" over the wire. Another lever closed the circuit, and lo and behold! there was the mechanical evidence that the operator had been awake and on the job, while the train dispatcher stood by the window and watched the "operator" sleeping profoundly.

In record time Edison was yanked up and stood on his feet, while the dispatcher poured into his half-awakened ears a harangue which brought the young inventor to his senses with a jump. Language was picturesque on western railroads in those days, and Edison had no difficulty in understanding that he was out of a job and that the quicker he cleared out of that office the better! He did, only trying to justify himself with the statement that nothing serious had occurred as a result of his sleeping to justify his dismissal.

His next offense, however, was more serious, and to this day Edison himself speaks of it a little shamefacedly. After having been dismissed from Port Huron, the young fellow was out of work for some weeks, but finally secured a position in Sarnia, Ontario, a Canadian point, also on the Grand Trunk Railroad. This was a day position, and consequently there was not the same opportunity to shirk work. But no routine, no matter how

close or detailed, sufficed to interest Edison for long; his mind craved the grappling with new problems. Accordingly, even at his work, he usually had a sheet of paper and pencil beside him on which he would work out problems which he desired to submit to experiment at a more propitious time.

On one of these occasions, while extremely interested in a question which afterwards he made useful in his quadruplex telegraph invention, he allowed a train which he had been ordered to stop, to run through his station. As this was definite negligence, the seriousness of the matter flashed on Edison the second that the train had passed, and he rushed out on the platform in a vain hope to attract attention. It was, of course, too late, and the boy ran down the line with his ears strained and his heart almost bursting from his ribs, every second fearing to hear the crash of an awful accident. Fortunately the locomotive engineers heard each others' whistles and the accident was averted by a narrow margin.

Edison was at once summoned to the office of the general manager, W. J. Spicer, a man noted for his severity.

"Young man," said Mr. Spicer, "this offense of yours is a very serious one, and I think I shall

make an example of you. I can send you to the penitentiary for five years and —"

"Just at this minute," continued Edison when telling the story, "two English swells came in and Mr. Spicer rose to greet them. They engaged him in conversation and I seized the chance to slip quietly out of the door. I headed for the freight depot where I found a freight train about to start for Sarnia. I knew the conductor, told him I'd been up to Toronto on a holiday excursion, and asked him to run me back to my station. He agreed. I stayed on that freight train right through, but my pulse didn't get down to normal while I was in Canada, until the ferryboat between Sarnia and Port Huron landed me in the United States."

At Port Huron he applied for a job to the Western Union Company and they took him on. He was there only a few months, however, leaving because of a dispute with the manager over a bonus which was to have been given for "taking" an important presidential message to Congress.

Hearing that the post of night operator at Stratford, Ontario, was vacant, he applied for the position and secured it without delay. The pay, however, was but twenty-five dollars a month, scarcely enough to live on, and Edison decided

that it was not worth his while to stay there, the more so as he had no conveniences for his private experiments. He threw up the position and started off for Indianapolis, where it was possible to secure more important posts. He stopped the superintendent of the Western Union Company in the street and asked for an interview. The latter, Mr. John F. Wallick, favorably impressed, told him to come in the next morning. Edison did so, and answered the questions that were asked him so promptly, and with such an evident understanding of the principles of telegraphy, that he was given a position in the Union Station at once. Here the pay was fair, and the work heavy. Being only routine, however, it did not suit Edison, and he petitioned for the "press wire." In this, however, he was unable to make good, and a few months later he was suspended for delay on the wire and transferred to Cincinnati.

Frequently, in later years, Edison has expressed his good fortune that the work of a telegraph operator should have been the line he took up when it was necessary for him to earn his living during the years best fitted for acquiring knowledge. He has since told the story of the happenings in the telegraph office in Cincinnati — on one of the most dramatic nights in American history.

"One night," he is quoted by W. K. L. Dickson as having said, "I noticed an immense crowd gathering outside a newspaper office across the street. I called the attention of the other operators to the crowd, and growing curious, we sent a messenger boy to find out the cause of the excitement. He came back in a hurry, dashed up the stairs two steps at a time, and just as he reached the door of the office, shouted,

"'Lincoln's been shot!'

"We had expected some local news, but just as soon as we realized that this dispatch must have come through our office, we glanced from one to the other to see who had taken the news and kept so quiet about it. All faces were blank and every man said he had not taken a word about the shooting.

"'Look over your files,' said the boss to the man handling the press stuff.

"For a few minutes we waited in suspense, and then the man held up a sheet of 'flimsy' containing a short account of the assassination of the President. The operator had worked so mechanically that he had handled the news without the slightest perception of its significance. I think," Edison concluded, "that I must have often been thinking up problems while I was at work, although, before

I quit, I was able to 'take' any stuff they liked to send along."

The suspension from the office at Indianapolis was a great shock to Edison's pride, for he realized that it was not due to his mind being occupied with other things, but solely to the fact that there were more rapid operators than himself. He buckled down to his work in earnest, and "subbed" for the night men every chance he got, once in a while managing to get a chance for an hour or so on the "press wire" during a slack period of the night. This was the cause of his promotion.

Coming down to "sub" one night, he found the entire night staff off on a spree, and peeling off his coat, the youth took the press report as best he could, working alone until morning. The very next day his salary was nearly doubled and he was given the Louisville wire, one of the best in the office. Fortunately for Edison, the "sender" at the Louisville end was one of the best in the country and at the same time both smooth and patient. This made things easy for Edison, and he soon got up speed enough to be able to handle the "press wire" with comparative ease.

The manager of the Cincinnati office, however, was somewhat of a stickler for appearance, and

nothing could make Edison careful. He spent all his money on books and appliances, and he spent nearly all his spare time in reading, with the result that one day he again found himself out of a position. By this time, however, he was one of the fastest operators the Western Union had on its payroll and one who was the despair of his rivals because of the ease with which he was able to "take" or "transmit." Francis A. Jones, in his biographical appreciation of Edison, quotes a Tennessee man who was an operator in the Western Union office at Memphis at the time the future Wizard applied for a job.

"He came walking into the office one morning," says this anonymous writer, "looking like a veritable hayseed. He wore a hickory shirt, a pair of butternut pants tucked into the tops of boots which looked too large for him and which, evidently, were guiltless of blacking.

"'Where's the boss?' was his query as he glanced around the office.

"No one replied at once, and he repeated the question.

"The manager asked what he could do for him, and the future great one proceeded to strike him for a job. Business was rushing and the office was two men short, so almost any kind of a light-

ning-slinger was welcome. He was assigned to a desk for a trial and a fusillade of winks went the rounds of the room, for the new arrival had been put on the St. Louis wire, the hardest in the office. At the end of the line was an operator who was chain lightning and knew it.

"Edison had hardly got seated before St. Louis called. The newcomer responded, and St. Louis started on a long report which he pumped in like a house afire. Edison threw his leg over the arm of the chair, leisurely transferred a wad of spruce gum from his pocket to his mouth, took up a pen, examined it critically, and started in about fifty words behind. He didn't stay there long, though. St. Louis let out another link of speed and still another, and the instrument on Edison's table hummed like an old-style Singer sewing machine. Every man in the office left his desk and gathered around the jay to see what he was doing with that electric cyclone.

"Well, sir, he was right on the word and taking it down in the prettiest copper-plate hand you ever saw, even crossing his 't's' and dotting his 'i's' and punctuating with as much care as a man editing telegraph for rat printers. St. Louis got tired by and by and began to slow down. Then Edison opened the key and said:

"'St. Louis! Hello, there! Change off, and send with the other foot!'

"Well, sir, that broke St. Louis all up. He had been rawhiding Memphis for a long time, and we were terribly sore. To have a man in our office who could walk all over him made us feel like a man whose horse had won the Derby. We took him out and gave him a dinner, but we never really succeeded in getting the look of the slick operator into him."

The Memphis office was full of a wild crowd, and after a particularly riotous night, the manager came in and dismissed several of them, including Edison, though he had taken little part in the fun. He was without funds, and he actually tramped all the way to Nashville and then to Louisville before he found another job. Realizing that to get the full benefit of his skill in telegraphy he must write as rapidly as any one could send, the young fellow developed a highly artistic "back-hand" which he could do at a speed of fifty words a minute, or as fast as a Morse operator could send. As this was before the days of typewriters, this last ability was the crowning cap of his efficiency.

Experiments, as ever, were his bane. As he spent on apparatus all that he could earn, Edison begrudged buying sulphuric acid, which he needed

for his tests, when there was a lot of it in the office where he worked. One night, while he was engaged in filling one of his own vials with acid from the general stock, the carboy tipped over and fell on the floor. The acid ran through the floor and the ceiling of a richly furnished directors' room of a bank, doing great damage. Edison was immediately discharged, both because of the damage and because he was not expected to help himself to office supplies.

His good judgment in spending time in developing his handwriting now showed itself. Having written to a friend in Boston, by name Milton Adams, to see if there was any chance for a job, Adams showed the letter to Mr. G. F. Milliken. The curious handwriting immediately attracted the manager's attention, and on learning from Adams that Edison could write that hand as rapidly as an operator could send, he was told to write to his friend and he would be given a chance.

Edison strolled in, looking as untidy as ever, but Milliken was a man of judgment, the very first to recognize in the young telegraph operator the spark of genius, and he overlooked many things which would have been cause for dismissal in another man. He was hardly ever on time, and often would arrive at the office half an hour or

even an hour late, owing to his intense concentration on some problem which he had been attacking that day in his little workshop. But the days of his life as a telegraph operator were drawing to a close, for the spirit of the inventor possessed him more and more, and, when he left Boston after a couple of years under Milliken, he had handled the key for the last time but one.

Twenty-six years later, at the Electrical Exhibition held at New York, when Edison's name was honored throughout the United States, he was asked to receive the message to be sent around the world by Chauncey M. Depew. In order to test his ability, he stepped into the telegraph room. As the familiar clatter and click of the instruments struck his ears, he tossed up his head.

"Sounds good," he remarked. "Good man at the other end?" he queried as he sat down and reached over for some telegraph blanks.

"Pretty fair," answered the manager.

Click — click — began the instrument, and Edison half wheeled round in his chair to nod approval.

"Good Morse," he said, "very easy to read. I doubt if I can put it down the way I used to, though."

He struck a match and proceeded to light one of his big cigars, writing steadily with the other

hand. He took the screed down without a flaw and with apparent ease, and then, to test his sending ability, turned loose on the man at the other end, repeating the message.

"I think I could receive or send if I lived to be a thousand," said the inventor, leaning back in his chair. "I don't believe a man would ever forget it. It read just like copperplate, but it kept me scratching to get it down."

CHAPTER V

"Never Watch the Clock!"

It is undeniably true that Edison's career as an inventor began while he was still a tiny toddler — has not the story of the goose's eggs been told? — but a turning point in his career is marked by the granting of his first patent. It is characteristic that this should be a device of value to the state. Just as, at the height of his career, Edison was willing to give his counsel to the national defense of the United States in a military fashion, so, in his youth, he wished to make his inventiveness of service to political and legislative life. Both bespeak the patriot.

This first patent of the great inventor's was a vote-recording machine. Edison, on the press wire, had taken many an account of an election or an important vote in Congress, and he knew how awkwardly this was done and with how many delays.

The "vote-recorder" was a complete system, arranged so that it might be attached to a switch

on the desk of every member of a legislative body. When a question came up for vote, the member, by moving the switch either to the right or the left, could register his vote on the machine at the clerk's desk. The paper on which the vote was recorded was chemically prepared, and when the member moved the switch and closed the circuit, an iron roller passed over the paper, under which was the type signifying the member's name. Whenever the type came in contact with the chemically prepared paper, it turned it a dark brown, thus practically printing the name on the roll of paper. An indicator registered the number of votes "for" and "against," thus insuring accuracy, giving a permanent record, and counting the votes instantaneously.

Edison took a trip to Washington and showed the recorder to several Congressmen who were on important committees. One of the most prominent, after examining the machine closely, said to him,

"Young man, so far as I can tell, that's a mighty ingenious little instrument you've got there and it seems to work well. You couldn't monkey with a thing like that if you wanted to. That's what's the trouble with it. If everything was on the square, and no one was trying to put any-

thing over, that machine would be a big help and save a lot of time. But it won't do."

"Why not?" asked Edison, naturally enough.

"Because there's got to be a chance to filibuster and delay, sometimes. Quite often a piece of bad legislation comes up unexpectedly, and if the men who want it could railroad it through, there'd be no chance of setting things right again. That machine of yours is just about the last thing we want here. You've got the right idea for an ideal state — but this isn't idealism, this is politics. Take the thing away."

"It broke me all up," said Edison, when he told the story afterwards, "because I knew the machine was a good one and I had counted on its bringing me in some money. But that was a good solid lesson to me. Right there and then I said to myself that I wouldn't ever put in time trying to invent something that wouldn't sell, or, at least, that wasn't of general good to the community. And, except for a few things which just happened into my mind — 'scratches' I call them — I have pretty well kept that vow."

Up to this time, it must be admitted, Edison had not "found himself." Nothing saved him but the fact that telegraph operators were scarce in that time of the rapid extension of the telegraph,

for, though a good operator, he was a poor employee. Milliken's confidence in him, however, encouraged his ambitions as an inventor, and though F. L. Pope, patent adviser of the Western Union Company, after a trial, decided that his duplex system was still far from perfect, he had held out hopes.

At this point Edison took the bull by the horns. Not with any return of his shiftless and wandering habits, but with a definite objective point, he resigned his position in Boston and came to New York. Sink or swim, he was going to make the world see the value of his ideas. He had no money — scarcely enough to pay two weeks' board, and the "inventing business" is one that takes a lot of capital.

At last, at long last, Fortune smiled directly upon him. The wheel of Chance swung his way. Walking along Wall Street one morning, he entered the head office of the Law Gold Recorder. The Recorder — which was the father of the stock ticker — was an electrical device which registered the fluctuation in the price of gold, in much the same way that the stock ticker to-day registers the rise and fall of the prices of stocks. It was much more primitive in its make, but it worked.

On this particular morning, the office was in an uproar. There had been a general breakdown of the system, — a matter of fairly frequent occurrence — gold was dear, minutes were flying fast and excitement was high. Mr. Law was standing by the broken-down machine with half a dozen of his most expert workmen, all trying to locate the trouble.

Suddenly Edison, who had been watching closely, piped up.

"I don't see any particular trouble there."

"Why?" asked Law quickly.

"I think I can fix it up, right away," the young electrician said modestly.

"Jump in and see what you can do," was the immediate answer.

Edison walked forward with one hand in his pocket, the other holding a small pair of tweezers. Without even troubling to take his left hand out of his pocket, he removed a loose contact spring which had become displaced and which had fallen between the wheels. Instantly the instruments worked as readily as before.

For a minute or two, Law watched young Edison.

"Clever machine, that," he said, to draw him into conversation.

"Ye-es," the inventor answered dubiously.

"Don't you think so?"

"In some ways," was the deliberate answer.

"Can you improve on it?"

"I haven't thought about it at all," came the modest reply, "but there's nearly always a way to better every machine."

The head of the concern looked him over.

"Come into the office," he said; "if you have any ideas about the ticker, I'd like to hear them."

The interview was brief and bewildering to Mr. Law. In his slow and deliberate way, young Edison laid out all the advantages and disadvantages of the principles of the system.

"When did you examine the instruments?" queried the head of the concern.

"I haven't had a chance to examine them yet," was the answer, "I could see that much while the other chaps were trying to fix it."

"I really ought to have some one to manage the service and see that it doesn't get out of gear so much," said Mr. Law. "Will you take the job? I can't pay more than three hundred dollars a month."

At the time this seemed fabulous riches to Edison, and nothing but his natural gravity and impassiveness kept him from showing his surprise,

but he accepted the position in what he felt to be the offhand way that was required.

In spite of the fact that he was manager of the service, however, the gold ticker broke down again and again. Edison was always able to attend to it instantly, and in consequence the customers were kept satisfied. Edison was not. In his judgment, a piece of electrical machinery was not satisfactory until it was at least ninety per cent perfect. He set aside his duplex telegraph plans to work on improvements in the ticker.

As some of these came into force, the Law Gold Recorder and another firm consolidated, and Edison, for a little while, was not quite sure where he was going to land. He soon took a similar position of electrician with the Gold and Stock Telegraph Company, whose president, General Marshall Lefferts, gave him every opportunity for developing his ideas. In the next couple of years Edison patented a host of stock printers or "tickers," one of which, with slight improvements, is the stock and news ticker of to-day.

One day two of the directors of the company stopped Edison in the brokerage room and asked him to come to the office of the president, stating that they wanted to take up with him the ques-

tion of purchasing the title to his inventions and improvements of the gold ticker.

"I had made up my mind," Edison has since said, "that five thousand dollars would strike me about right, but I would take almost anything, rather than not sell, as I needed money sorely for further experiments.

"'Well, Mr. Edison,' General Lefferts said, 'how much do you want for your devices?'

"'I do not know how much they may be worth to you,' I answered. 'Make me an offer.'

"'How would forty thousand dollars strike you?'

"I believe you could have knocked me down with a feather, so astonished I was at the sum. But the check was handed over two days later, after I had signed a large, formidable paper, about as intelligible to me as if it were written in Choctaw. In thirty days I had a shop of my own, fully equipped with all I needed, an investment which left me very little of the money I received from the ticker patents."

A second example of good fortune gave Edison an assured position in the world of invention, and, by a coincidence, it happened in very much the same way as the first. Edison had been in the habit of burning up the road to the office of the president of the Western Union every other

week or so, for he was absolutely convinced of the value of his telegraphic inventions, and he knew that there was no organization which could take them up with as much profit. Dr. Norvin Green, who was president at that time, had a great respect for age and — like many an old-fashioned man — believed that discipline was a wholesome corrective for youth. He could not be persuaded that such vast plans as those outlined by Thomas Edison could be of any value, since they were conceived by so youthful a personage.

It chanced that on one of these visits, when he actually succeeded in getting into the sanctum of Dr. Green, he found that gentleman in a highly irritated state. Indeed, he was so irascible that he found it necessary to half-apologize for it by stating that the company was unable to get into communication with Albany, their line repairers were all at fault, and that a great deal of important business was being delayed.

"What's wrong?"

"What the Blue Peter should I be sitting here fuming about, if I knew what was wrong?" retorted the magnate. "Perhaps, since you think you know such a blame lot about telegraphy, you might undertake to fix the trouble!"

Edison caught the sarcasm in the tone and it stung him a little.

"Dr. Green," he said, "all that I'm asking you to do is to give my inventions a fair consideration and an honest trial. If I locate this trouble for you within three hours, will you promise to give my ideas their chance?"

The president stared at him.

"Do you really think you can do it?" he inquired.

Edison wasted no words.

"Yes," he answered.

"Very good, then," said the head of the Western Union. "I'll be as good as my word. If you get us out of this fix within thirty-six hours, I will guarantee that your inventions are put forward and given every consideration that their merits warrant."

Edison jumped from his chair and made a bee line for the main office. He was known as an expert operator and a good many of the men knew of his improvements on the stock ticker, so that every assistance was afforded him.

"At the main office," said Edison, when telling the story himself, many years later, "I called up Pittsburg and asked for the best operator there. When I got him, I told him to call up Albany

and get hold of the best operator in that place to wire down the line toward New York so far as he could and report back as soon as possible. Inside of an hour I received this message:

"'I can get to within two miles of Poughkeepsie and there is trouble with the wire there.'

"I hurried back to the office of the president and told him that if he rushed a train to Poughkeepsie, the repair men would find a break two miles on the other side of the station and it could be fixed up that same afternoon."

In order to be able to give up routine work on a salary basis and give his whole time to experimentation, Edison resigned as manager of the Gold and Stock Indicator, and opened up a factory in Newark, N. J., manufacturing his improved tickers, for which there was a great demand. This was his first definite step into the industrialization of his inventions.

While he was most busily engaged in supervising the manufacture of these tickers, Edison married his first wife. It was in connection with this marriage that the notorious — and incorrect — story is told of his having absolutely forgotten the fact of his marriage.

"It's just one of those yarns the boys have to put up when they're short of news," Edison has

since stated. Then continuing, he is reported by F. A. Jones as having said: "That annoying story was got up by an imaginative newspaper man who knew that I was a bit absent-minded. I never forgot that I had been married. In fact, I don't believe any man would forget such an event unless he wanted to. But perhaps there was something to account for the story, and I think it must have been this:—

"The day I was married, a consignment of stock tickers had been returned to the factory as being imperfect and I wanted to find out what was wrong. Just about an hour after the marriage ceremony had been performed I thought about those tickers, and as soon as we got home I told my wife about them and said I would like to go down to the factory. She agreed at once and I went down, where I found Bachelor, my assistant, hard at work trying to remedy the defect. We both monkeyed about with them, and finally after an hour or two [the inventor is not famous for his sense of time, and it might have been nine or ten hours, as other reports say] we put them to rights and I went home again.

"As to forgetting that I was married, that's all nonsense, and both I and my wife laughed at the story, though when I began to come across it

every other week the tale began to get tedious. It was one of those made-up stories which stick, and I suppose I shall always be spoken of as the man who forgot his wife an hour after he was married."

Apropos of the inventor's reference to "an hour or two," it is worthy of comment that Edison seldom carries a watch. There is no clock in the chemical laboratory where he works most of the time. The minutes of his day are ticked off by accomplishments, not by the figures of a dial.

As characteristic a piece of advice as ever was given by the inventor was that which he gave to the son of a well-known English scientist. The proud father, after having introduced the lad, begged the Wizard to say something to the boy which he could remember as having been the most valuable piece of advice given to him in his life.

Edison, who is modest to the point of confusion, utterly disclaimed any power to issue an epigram or piece of sage counsel to the boy at a moment's notice. But the visitor begged so hard that the inventor turned his mind to the philosophy of his actions instead of to the actions themselves. Then, after a moment's thought, he put his hand on the boy's shoulder and with a kindly smile said,

"My boy, never watch the clock!"

CHAPTER VI

Building a Phantom Telegraph

"Electricity," said a schoolboy once, in an examination on physics, "is that something you can't see and don't know anything about, that will do anything you want without your knowing how it does it."

In a way, the boy's definition, while it could hardly be called scientific, somewhat represents Edison's own ideas about electricity. He is a kindly natured man and enormously patient, but it is on record that he once delivered himself of a strong opinion about those of his callers who ask questions about theoretical causes.

"What I hate," he said, "is when I have tried to explain a little of the wonders of the electric current, to have some young college freshie say,

"'Well, after all, Mr. Edison, we don't know what electricity really is, do we?'"

To Edison, electricity, like all science, is not so much a matter of knowledge for the sake of knowledge, as it is the use of the mysteries of nature for

the betterment of the human race. The distinction between Franklin and Edison is great. It is the distinction between the prospector and the miner. Franklin went far to determine the relation of electricity to nature; Edison has constructed the path between the electrical forces of nature and the service of man.

The electric telegraph as a commercial success owes its completion to Samuel F. B. Morse and Chas. Wheatstone, but its power as an agent in the progress of the world is due to Edison. "The Wizard's" contribution to the telegraph was the invention of the duplex and quadruplex systems, by which one wire can be made to carry two or four messages. This not only increases the commercial value of every wire twofold or fourfold, as the case may be, but it also correspondingly reduces the cost of upkeep and repair.

The value of the duplex and quadruplex systems can best be understood if one thinks of the quadruplex system as being a plan by which one wire is made to serve the purpose of four. It is almost as though three phantom or ghostly wires, which have no real existence, were strung parallel to the true wire. The manner in which this is accomplished is easily understood once the principles of telegraphy are made clear.

In 1831, Michael Faraday, experimenting on magnetism, discovered that a piece of iron could be made into a magnet by winding a coil of insulated wire round it, and passing a current of electricity through the coil. The iron, however, was not permanently magnetized, but was a magnet only so long as the current was flowing through the coils. When the current stopped, the magnetism ceased. This holds true, no matter how quickly or how often the current is put on and off, or, in the usual phrase, no matter how often one may "make" and "break" the circuit. To make or close a circuit is to give a continuous wire through which the current may flow; to break or open a circuit, is to put a gap at some part of the wire, preventing the flow of the current.

If a metal hammer, or armature, is so arranged that it is held by a spring at a short distance above a soft-iron core wound with insulated wire connected with a galvanic battery, it is obvious that when the current is passing along the wire, making the soft iron a temporary magnet, the metal hammer will be drawn against the iron. As long as the current flows, and the iron remains a magnet, the hammer or armature will remain held by it, in spite of the spring. As soon as the

current is stopped, and the iron ceases to be a magnet, there is nothing to attract the hammer and it flies back with the pull of the spring.

As the magnet can be made very powerful by wrapping a large number of coils around it, the hammer can be made to come upon the iron with such force that a sharp "tap" is produced. Then, it is clear that if an alphabet be arranged which is based on the number of "taps," or the time between them, words can be spelt and electricity can convey a message.

From this point it is easy to see that if a key be so arranged that by pressing a button a circuit will be "made" or "closed," and by releasing it the circuit will be "broken" or "open," an operator using the key at one end of a wire may cause a hammer or armature to give a series of corresponding "taps" at the other end of the wire. This button arrangement, which is called the "transmitter," may be at any distance from the magnet and hammer, since the passage of electricity is practically instantaneous.

In actual practice it was found by Morse that the current feebled in passing over a long stretch of wire, so that it was too weak to make a magnet strong enough to attract a hammer with force enough to make a sufficiently loud "tap." To

avoid this, Morse adopted a system of strengthening the current at certain intervals with "relays." The idea was first advanced by Professor Henry of the Smithsonian, improved by Morse, and perfected by Edison.

The importance of the "relay" cannot be overestimated. If, at a considerable distance, the current becomes too weak to work the tapper, and if the working of the tapper is the crucial point in telegraphy, it follows that the system is dependent on some means whereby the weak current, at a long range, can powerfully operate a tapper. This is the purpose of the relay.

In the relay, the tapper is not on the main circuit, but on a separate powerful local circuit. On this local circuit is a light "make and break" device, to be controlled by the main line. The main line, by this means, does not enter the local station at all, it does not go through it, but it operates either to let the strong local current pass, or not.

When the main line approaches the local circuit, it goes round a light piece of soft iron. Immediately opposite this soft-iron magnet is the break in the local circuit, a light lever being held back by a light spring. When there is a current (from a message) on the main wire, it magnetizes

the light soft iron, and pulls the lever forward. It is not allowed to reach the magnet — as this would draw current from the main line — but meets the other point of its own circuit, closing it, sending the current through and operating the tapper. When the main line current stops, the light magnet becomes demagnetized, the lever flies back, breaking the local circuit, and the tapper flies back, operated by its spring.

As the operator, in a distant town, moves his key up and down, spelling words in the Morse code, thus opening and closing the main line circuit, so does the little lever move, opening and closing the powerful local circuit which works the tapper. Thus the listener hears in loud sharp clicks the message that is being sent from a distant sending station, though the original current itself never comes upon his wire.

To use this wire for more than one message at a time was Edison's aim. He was by no means the first. In 1853, Dr. Gintl, an Austrian, invented a duplex system, as did Carl Frischen of Hanover. There were various others, especially the "Stearns" and the "Polar" systems. All had some weak point. They had come to the "I don't know" point, and Edison set out to find the "why" of it. He found the reason, overcame

the obstacles that had halted his predecessors, and devised his working system of duplex telegraphy. This he patented, and this was the basis of his constant bombardment of the Western Union Telegraph Company. As has been shown, he secured a hearing for his invention, and later sold it to the Western Union.

By Edison's instrument, two messages can be sent in opposite directions over the same wire at the same time. The attempt to run two trains on a circular track simultaneously in opposite directions would mean sure disaster, but in duplex telegraphy, messages do not conflict.

The principle on which this system works is, that currents of electricity may be split up and then will follow any number of paths that may be opened to them exactly in proportion to the resistance that the wire offers to their passage. This is in much the same way that water, flowing through a set of pipes, will fill them in exact proportion to their size. In Edison's apparatus, this principle is so fully carried out that the apparatus at each end pays no heed to the movements of its own transmitting key, although at the same time it responds to every movement of the key operated at the distant station, no matter how far away.

Duplex and diplex telegraphy, both of which are included in Edison's system, are developments of the simple electromagnetic principle of the telegraph. It will be remembered that a wire wound round a soft-iron core, transforms that core into a magnet when the current passes through the coil. But if two wires are wound round the coil, in opposite directions to each other, the currents will neutralize and the iron will not become magnetized.

Suppose a wire laid from New York to Philadelphia. From a battery in New York issues a current which is divided into two wires, wound in opposite directions round a core. One wire is grounded, one is the main line to Philadelphia. The current passes through each wire with equal strength. In one wire the current goes to the ground, through the other it passes on. It is clear that the soft-iron core near New York has not been affected, for the currents neutralized. It is clear also that a similar soft iron core in Philadelphia will be affected, since the current is passing only in one direction. An armature, or hammer, in Philadelphia, therefore, will be made to sound by the operating of a key in New York, although the New York tapper has been unaffected.

If, at the same time, a current is started at Philadelphia, in like fashion (because its currents neutralize) it will not affect the Philadelphia sounder, which is being kept busy from the New York end, but it will also pass along the main line wire to New York, and, since it is a current flowing only in one direction, will circle the coil, magnetize the core, and start the sounder there, Thus New York will be receiving Philadelphia, at the same time that Philadelphia is receiving New York, yet each receiver will be unaffected by the transmitter at its own end.

About two years later, in 1874, Edison secured a patent for his quadruplex system, easily the most important asset in telegraphy since the work of Morse. In this, the principle is due to the fact that the direction in which the coils are wound around a core determines its polarity, or, in other words, which shall be the positive and which the negative end of the magnet. In working operation, a steel magnet is used. Steel, unlike soft iron, retains its magnetism permanently. As a negative pole will repel and a positive pole will attract, a device which causes the current to flow in opposite directions alternately around a soft-iron core, will alternately repel and attract the permanently magnetized steel.

By combining instruments that only respond to strength of current with those that respond only to change of current, and by utilizing the duplex plan of using the same wire for currents going in opposite directions, the two systems can be worked from each end. Thus four sending and four receiving operators, or eight in all, may be kept busy on a single wire.

The actual value of this invention is stupendous. Although Edison sold it to the Western Union for thirty thousand dollars, it has been worth to that company at least thirty million dollars. And even then, Edison made not a single penny profit on it, for he spent all his thirty thousand dollars in perfecting a sextuple telegraph, by which a wire could carry six messages. As an invention it was perfect, but it did not prove a commercial success.

It was while he was trying in vain to explain the character of the sextuple telegraph to a prominent visitor, through whose royal skull he was unable to make the information penetrate, that Edison gave what he says he considers the easiest, though not the most accurate, illustration of the nature of electricity.

"Your Royal Highness," he said, "I think the best explanation of the nature of electricity was

one which I heard an old Scotch line repairer once give to his assistant.

"'If you had a dog something like a dachshund,' he said, 'only long enough to reach from Edinburgh to London, and you pulled his tail in Edinburgh, he would bark in London.'"

"That," the inventor went on to say, "is as far as I can get. I can't tell you exactly what goes through the dog or over the wire."

A successful modification of Gray's harmonic multiplex telegraph, an automatic telegraph and an autographic telegraph, were invented by Edison during the days when his headquarters were at Newark. Indeed, he has always been interested in the autographic telegraph, and threatens yet to return to it and displace the telegraph operator entirely. Perhaps, however, a fellow-feeling for the craft that sustained him through his early years may cause him to forbear.

It was with reference to his steady and unremitting work on the quadruplex and sextuplex telegraph that Edison made the famous statement about "genius" which has since passed into a proverb.

"How can you deny yourself the inspiration of genius, Mr. Edison?" an admirer said one day in the laboratory at Orange, after seeing some of his

telegraphic inventions. "Surely you don't mean to try and convince me that anybody could have done all this work that you have done and invented these incredible marvels?"

"Well, as to that," said the inventor reflectively, "seems to me I hear of something new done by somebody or other, nearly every day," and he rattled off a string of names that showed how closely he kept in touch with the advances in practical science all over the globe.

"But the genius!" protested his admirer. "The flash of inspiration!"

"Oh, I don't know," was the reply, as the "Wizard" turned round and put one fist in his pocket, and rubbed a rough chin with the other chemical-stained hand; "the way I look at it, seems to me that genius is about two per cent inspiration and ninety-eight per cent perspiration."

And he went on with his experiment.

CHAPTER VII

The Great Telephone War

"When I struck the telephone business," Edison said, once, when asked to explain his connection with the improvement of the 'phone, "the Bell people had no transmitter, but were talking into the magneto receiver. You never heard such a noise and buzzing as there was in that old machine! I went to work and monkeyed around, and finally struck the notion of a lamp-black button."

The telephone was almost invented by Charles Bourseul, a Frenchman, in 1854. It is pathetic, in a way, to see how nearly Bourseul attained success, and yet how utterly the one tiny wrong point in his plan rendered the idea useless. What was more, this one mistake led every one else astray, so that it was not until nearly a quarter of a century later that the world received its telephone. Even then, the instrument was of little commercial value until the wizard touch of Edison solved its last difficulty and made it available for general use.

Bourseul originated the whole telephone idea in the following words: —

"I have asked myself if the spoken word could not be transmitted by electricity; in a word, if what was spoken in Vienna may not be heard in Paris. This thing is practicable in this way:

"Suppose that a man speaks near a movable disk, sufficiently flexible to lose none of the vibrations of the voice; that this disk alternately *makes and breaks* the connection from a battery; you may have at a distance another disk which will simultaneously execute the same vibrations."

The italics tell the tale. The reasoning, sound as it seems, is on a false basis. This was proved in 1861 by Philip Reis, a German scientist.

Reis was the inventor of the word "telephone," just as Edison was the originator of the word "Hello!" in telephone usage. Reis built his "tele-phone," following Bourseul's ideas in every detail. He experimented with it a great deal and succeeded in getting an instrument which could register the waves of sound with extreme accuracy. But it had one fatal and ineradicable fault. It could only give pitch, not tone.

Thus, for example, G natural on a musical scale and C natural on a musical scale, are different notes because the number of vibrations differ,

the lower note having the fewer number of sound-waves or vibration, and the higher note having a larger number of vibrations. The Reis receiver would record these with absolute faithfulness. But — and this was fatal — no one could tell whether the note was the product of a flute, a horn, a violin, or the human voice. Moreover, a sound just barely sufficient to break the circuit, produced almost as much effect as a loud trumpet blast. An alphabet of pitch could be devised, so that the Reis system could be used as a sort of telegraphy based on sound, but the modulations of the human voice were beyond it.

Then came one of the most extraordinary coincidences in the whole history of invention. On the very same day, absolutely without knowledge that the other was working on the problem, Professor Elisha Gray and Dr. Alexander Graham Bell filed application in the Patent Office for identically the same (and the true) principle of telephone transmission. A sensational contest followed. It was finally adjudged by the courts that Bell had been two hours (!) earlier, and also that his appreciation and understanding of the discovery was slightly more complete than that of Gray.

"It was left for Bell," says a decision of the Supreme Court of the United States, in 1887,

"to discover that the failure [of the Reis apparatus] was due not to workmanship, but to the principle which was adopted as the basis of what had to be done. He found that what he called the intermittent current — one caused by alternately opening and closing the circuit — could not be made under any circumstances to reproduce the delicate forms of the air vibrations caused by the human voice in articulate speech, but that the true way was to operate on an unbroken current by increasing and diminishing its intensity. . . . Such was his discovery, and it was new. Reis never thought of it, and he failed to transmit speech telegraphically. Bell did, and he succeeded. Under such circumstances it is impossible to hold that what Reis did was an anticipation of the discovery of Bell. To follow Reis is to fail, but to follow Bell is to succeed. The difference between the two is just the difference between failure and success."

The story of Edison's contribution in commercializing the telephone has been told by the inventor himself.

"In 1876," he said, "I started again to experiment for the Western Union and Mr. Orton. This time it was the telephone. Bell invented the first telephone, which consisted of the present

receiver, used both as a transmitter and a receiver (the magneto type). It was attempted to introduce it commercially, but it failed on account of its faintness and the extraneous sounds which came in on its wires from different sources. Mr. Orton wanted me to take hold of it and make it commercial. As I had also been working on a telegraph system employing tuning forks, simultaneously with both Bell and Gray, I was pretty familiar with the subject. I started in, and soon produced the carbon transmitter which is now universally used.

"Tests were made between New York and Philadelphia, also between New York and Washington, using regular Western Union wires. The noises were so great that not a word could be heard with the Bell receiver when used as a transmitter between New York and Newark, N.J. The Western Union then put them on private lines.

"Mr. Theodore Paskas of Budapest, Hungary, was the first man to suggest a telephone exchange, and, soon after, exchanges were established. . . . The Bell Company, of Boston, also started an exchange and the fight was on, the Western Union pirating the Bell receiver and the Boston company pirating the Western Union transmitter.

"About this time I wanted to be taken care of. I threw out hints of this desire. Then Mr. Orton sent for me. He had learned that inventors didn't do business by the regular process, and concluded that he would close it right up. He asked me how much I wanted. I had made up my mind that it was certainly worth $25,000 if it ever amounted to anything for central-station work, so that was the sum I had in mind to stick to and get — obstinately. Still, it had been an easy job, and only required a few months, and I felt a little shaky and uncertain. So I asked him to make me an offer. He promptly said that he would give me $100,000.

"'All right,' I said, 'it is yours on one condition, and that is that you do not pay me all at once, but pay me at the rate of $6000 per year for seventeen years' — the life of the patent. He seemed only too pleased to do this and the deal was closed.

"My ambition was about four times too large for my business capacity, and I knew that I would soon spend this money experimenting if I got it all at once, so I fixed it that I couldn't. I saved seventeen years of worry by this stroke."

The operation of the carbon transmitter is quite simple. A button-shaped piece of carbon

is held by a light spring against the diaphragm into which the telephone message is spoken. This carbon button is placed in circuit with the primary wire of an induction coil, the battery being in the same circuit and the secondary of the induction coil connected to the line.

When the diaphragm is set in vibration by the sound waves of the voice, a varying pressure is applied to the carbon button. Now a loose contact between two pieces of conducting matter has the remarkable property of conducting a current better when the pressure on it increases. Pressure on the carbon button brings the molecules of carbon in closer contact. With every change of the voice, and every different vowel and consonantal sound, there is a variance in the movements of the diaphragm. This different vibration of the diaphragm means a difference in the pressure on the carbon button, and this again means a difference in the electrical resistance. Thus wide variations of current are produced in the primary, and consequently similar changes in the induced current are set up in the secondary. These induced currents are sent into the line and act on the receiver at the distant station.

It is almost incredible how little electric power is required to operate a telephone. For example,

the power required to burn one ordinary sixteen-candle-power incandescent carbon electric light bulb for one minute, would send a message from the Earth to the Sun and back again twenty-five times, while the electrical energy required to lift a pound weight a foot high would be sufficient to operate a telephone for 240,000 years.

The principle of the variable resistance of carbon in proportion to pressure was taken advantage of by Edison in his tasimeter. This extraordinary instrument is so delicate that it has been used to register the heat contained in the light of a star, and the warmth of a hand held thirty feet away causes so violent a movement as to whirl the needle to the limit of the dial.

A bar of some substance, such as vulcanite, which is extremely sensitive to heat, rests upon a metal plate, generally of platinum, which in its turn rests upon a carbon button, itself upon a second plate, of platinum. The carbon and the metal plates are connected in a circuit which includes a battery and a sensitive galvanometer. Thus, even an infinitesimal variation in the length of the rod of vulcanite due to its contraction or expansion, its shortening or lengthening, affects the resistance of the circuit to precisely the same extent, and the galvanometer duly records the

change. The same instrument, with a strip of gelatine in place of the hard rubber, is used in determining the character of gases. In other words, it measures a smell. Its principal purpose, however, is to measure extraordinarily small degrees of moisture.

Although there are many forms of microphone, one of which was claimed by Professor Hughes of England to be the first, perhaps the most efficient is the Edison microphone, in which carbon is used again, but in which the carbon is in the form of small granules, a loose contact being far more sensitive. With this instrument, the rustling of tissue paper sounds like a hurricane at sea.

The Edison carbon pressure relay follows the same principle, the poles of an electro-magnet in the local circuit of a telegraph line being hollowed out and filled with powdered carbon. With a weak current the armature is attracted weakly with a feeble click; with a strong current, the armature will have a strong attraction and a loud click.

No sooner was an effective commercial telephone secured than the inventor was clamorously summoned by the Western Union to help them out of a new hole, and as the resulting invention was later used in telephonic improvement it may well find a place here.

While Edison was busily engaged in perfecting his telephone, while, indeed, he was taking out patents for the water telephone, the inertia telephone, the electrostatic telephone, the voltaic pile telephone and a "musical transmitter," the Page patent, which had lingered on in the Patent Office for years, was issued. This was a black menace to the existing systems of telegraphy. It related to the use of the spring which pulls back the armature lever from the magnet of a telegraph relay or sounder, when the current is cut off. At one swoop this broke in and controlled one of the most important features of telegraphy, save for the simple circuits, and these, of course, could not be used for long distances.

"There was no known way," Edison is quoted by Messrs. Dyer and Martin as having said, "whereby this patent could be evaded, and its possessor would eventually control the use of what is known as the relay and sounder, and this was vital in telegraphy. Gould was pounding the Western Union on the Stock Exchange, and being advised by his lawyers that this patent was of great value, he bought it.

"The moment Mr. Orton heard this he sent for me and explained the situation, and wanted me to go to work immediately and see if I couldn't

evade it or discover some other means that could be used in case Gould sustained the patent. It seemed a pretty hard job, because there was no known means of moving a lever at the other end of a telegraph wire except by the use of a magnet. I said I would go to work at it that night.

"In experimenting some years previously, I had discovered a very peculiar phenomenon. This was that if a piece of metal connected to a battery was rubbed over a moistened piece of chalk resting on a metal connected to the other pole, when the current passed, the friction was greatly diminished. When the current was reversed, the friction was greatly increased over what it was when no current was passing.

"Remembering this, I substituted a piece of chalk rotated by a small electric motor for the magnet, and connecting a sounder to a metallic finger resting on the chalk, the combination claim of Page was made worthless. A hitherto unknown means was introduced in the electric art. Two or three of the devices were made and tested by the company's expert. Mr. Orton, after he had me sign the patent application and got it in the Patent Office, wanted to settle for it at once. He asked my price. Again I said,

"'Make me an offer!'

"Again he named $100,000. I accepted, providing he would pay it at the rate of $6000 a year for seventeen years. This was done, and thus, with the telephone money, I received $12,000 yearly for that period from the Western Union Telegraph Company."

In order to make this a little clearer, it may be said that the passage of the electric current acts on chalk, as oil. Thus a pad pressed hard against the drum of chalk would be carried forward by friction as long as there was no current, the force of the friction being stronger than the weak spring attached to the pad. But, as soon as the current was applied, this had the effect of preventing the friction or making the surfaces seem as though oiled, so that the spring was able to exert its action, thus pulling back the pad, the alternate friction and release "making and breaking" a circuit with the same effect as the electro-magnetic system, which had previously been the only method known.

This was a scientific discovery of great moment. It was in no sense an improvement on anything that had been done before, but represented an absolutely new element in electric problems.

The loud-speaking telephone grew partly out of a difficulty encountered by Edison in his es-

tablishment of his telephone in England. A company had been formed, the instruments manufactured and sent to England under the direction of Colonel Gouraud, and it seemed as though there was likely to be a great success made there.

But the owners of the Bell patent had no intention of allowing the English market to be exploited without their having a finger in the pie. Gouraud cabled to Edison, saying that he was up a tree. He could do nothing unless a new receiver was invented which could in no way be regarded as an infringement of the Bell patent.

Having determined this new factor of the friction and lubrication by means of the passage of an electric current, Edison was able to use precisely the same principle in the telephone receiver. In the chalk receiver there was no magnet at all, merely a diaphragm of mica and a cylinder of compressed chalk a little larger than the top of a finger. A thin spring extending from the center of the diaphragm rested on the chalk cylinder with a pressure of a little more than five pounds. The sound was extraordinarily clear, but one of its disadvantages was that the chalk needed to be rotated by hand. The instruments, nevertheless, were absolutely efficient, and it was merely a matter of time until an automatic rotator would be perfected.

After about a hundred of these machines had been put in operation, the fact was duly impressed upon the Bell people that the Edison company could not be bluffed out, but that an absolutely efficient rival was in the field. Naturally enough they offered terms, the figure cabled being "30,000." Edison accepted, thinking the sum to mean dollars. It was a surprise of the most pleasant kind when the check arrived, being made out for thirty thousand pounds sterling.

The loud-speaking telephone was a development of the chalk receiver idea. George Bernard Shaw, who in his youth was employed by Edison in the establishment of telephone exchanges in England, described this loud-speaking device as being "a much too ingenious invention, being nothing less than a telephone of such stentorial efficiency, that it bellowed your most private communications all over the house, instead of whispering them with some sort of discretion."

When first working on the telephone, and again when working on the phonograph, Edison prophesied that some day there would be a combination of the two. It was his plan to invent an instrument which would record telephone conversations, so that they might be repeated again, when necessary. For example, if a customer

wanted to give an order, instead of the usual "Excuse me, while I get a pencil!" and then the tediousness of writing down the conversation, the machine would simply record the whole conversation, and the recipient of the message could afterwards go over it, and check off, item by item. The instrument, also, would prevent mistakes, as the record would be permanent.

This device, forecasted in the seventies, was perfected by Edison in September, 1914. He called it the "telescribe." It is practically a sensitive diaphragm attached to an Edison dictating machine (or phonograph recorder) which, when placed in direct contact with a telephone receiver, will make a record on the cylinder. The repetition of the message is merely the reproduction of the cylinder in customary phonographic form.

With the addition of the "transophone," also perfected in the autumn of 1914, this "telescribe" is made very effective. The "transophone" is a device enabling a stenographer, writing from a dictating machine, to touch an electric button and hear over again the sentence to be written. Thus, nearly forty years after his first prophecy of the combined telephone and phonograph, in his new "telescribe," Edison has brought it to triumphant success.

CHAPTER VIII

Outrivaling Aladdin's Lamp

From Edison's point of view, his greatest achievement is the perfection of the incandescent electric light. In this, as in so large a number of Edison's wonders, the initial foundation was laid by others. It remained for the "Wizard" to develop these, to do what the others could not or did not do, and to transmute phenomena which were merely of scientific interest into inventions of paramount importance to the world.

The history of electric lighting antedates Edison by some millions of years. The lightning flash is a case of pure electric lighting and its vividness immediately suggests its usefulness to man if only the amount of current can be subdivided. Electric lighting is the subdivision of electric lightning. The first man to think of harnessing the lightning for the purpose of using it for lighting purposes was the creator of the idea of electric light.

Benjamin Franklin may be given the credit for much of the original idea. In his famous experi-

ment, when he sent up a kite bearing a pointed wire into an electrical cloud, and held a metal key near to the silk string by which the kite was flown, thereby securing sparks from it, he showed a perception of the possibilities of subdivision. It was to him, certainly, that the credit is due for having shown that the disruptive and fatal effect of lightning could be modified, so that it would flow smoothly down the kite string. Franklin calmly risked his life to prove this point, and he proved it to his own fame and the lasting benefit of mankind.

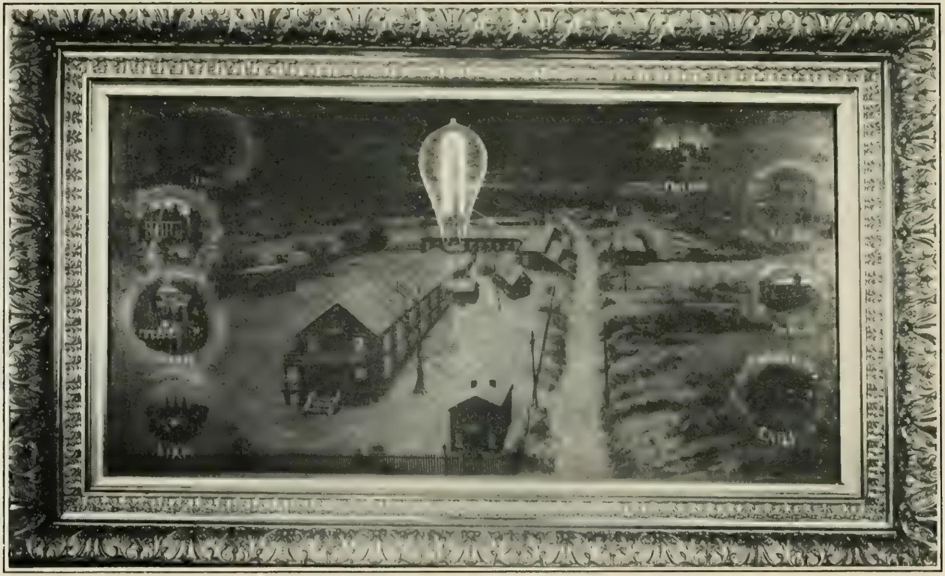
The study of electricity resulted in the realization of the fact that this force could be generated on earth as well as in the skies. It was evident, therefore, that the lightning flash could be made in the laboratory. As a matter of fact, the electric "spark" that leaps across a gap is this same lightning flash on a smaller basis. The question was — how to secure permanence to the sudden illumination.

Sir Humphry Davy, in 1800, discovered that if a current was established in such a way that it would flow through two conductors, and these conductors were slightly separated, a flash would be emitted. The extreme heat of this flame led Davy to experiment with various noncombustible

and rarely fusible substances, until he tried carbon. He found that if the current were sufficiently powerful, the flame would continue and the carbon points would become hot, first red-hot, then white-hot. When white-hot they emitted a brilliant light.

When the carbon points were separated, the extra potential induced by the self-induction of the circuit was enough to jump across the gap, and a small quantity of the carbon was vaporized. The resistance of carbon vapor to electricity is large, or in other words the friction of the electric current passing through the resisting particles is high, which causes the vapor to be raised to a very high temperature, and to emit a very brilliant light.

The principal trouble that Davy experienced was that the character of the charcoal he used was not commercially efficacious. He had made his carbons of the charcoal from the wood of the willow. As, in such a light as the Davy arc light, the electric current flowing from the positive to the negative carries away with it a constant stream of carbon particles from the positive electrode (hollowing it out), and deposits them on the negative electrode (bringing it to a point), and as a certain amount of the carbon was vaporized,



The Birthplace of the Electric Light

Photograph of a picture of Menlo Park Works, where Edison won the name of "The Wizard," and from which came man's power to turn darkness into day. The picture hangs in Edison's home.

it was not long until the points would burn away. As they burned away, the distance between negative and positive would grow larger until the gap widened to a point where the current would not leap it, and the light went out.

Modern arc lighting uses much the same principle, though the carbons are more durable, petroleum coke, gas coke or lampblack being used. The modern arc light is also provided with a mechanism to bring the carbons together to start the current, then to separate them a certain distance apart and maintain them at exactly that distance, irrespective of the rapidity with which they may burn away.

The idea of the incandescent lamp dates back to the year 1812. But every early effort to secure the brilliant white light by the heating of a conductor failed from the same reason — namely, that the melting point of the metal conductors was so near the temperature that was required to bring them to a white heat, that a very slight increase in the current immediately destroyed the conductor.

Among these experimenters, an American, J. W. Starr, takes high rank for being the first to substitute carbon filaments for platinum. Though, years later, Edison was to work on this line and

bring success where all others had failed, it is not to be forgotten that the original idea of the carbon filament is still the product of a United States inventor, and that the first patent for a carbon filament is recorded in the Patent Office at Washington. When it is remembered what the incandescent light has done for mankind, how — in a word — it has enabled man to have daylight for twenty-four hours if he chooses, the work begun by Starr and brought to a successful conclusion by Edison ranks as one of the most notable scientific achievements of history.

Prior to the discovery of the carbon filament, Edison experimented a great deal with metal filaments, particularly platinum. This metal was selected because of its susceptibility of being drawn out into fine wire and because its fusing or melting point is very high.

The experiments with platinum wire were brought by Edison to a point nearer perfection than was secured by any other of the dozens of inventors who were working on the problem, both in Europe and the United States. To put the whole series of experiments in a few words, Edison found that platinum wire, heated in a flame of hydrogen, lost weight, and finally was burned away. Next he found that platinum

wire, heated so that it was white-hot or incandescent, lost weight, a wire one five-thousandth of an inch in diameter losing three milligrammes in twenty minutes. A wire one twenty-thousandth part of an inch in diameter, placed under a glass shade, lost at the same rate, and the sides of the glass were so heavily coated with the deposit that the glass became opaque and the glowing wire was invisible. This made the burning of pure platinum wire in the open air a commercial impossibility.

At this point Edison started work on the wire itself, experimenting with various alloys of platinum, especially zircon and iridium. Many weary months were spent in a ceaseless series of experiments, all of which tended to the same conclusion — failure. Then it was that Edison, carefully studying the loss in weight of all these metals when heated to incandescence, declared his belief that this was due to the "washing action of the air," and that a great deal of the difficulty might be avoided if the light were burned in a vacuum, a glass bulb from which all the air had been exhausted by an air-pump. When the bulb was partly exhausted of air, the platinum wire burned for two hours before the glass blackened, and when the air was exhausted still further, it burned for five hours.

Finally, to use the inventor's own words, "In a sealed glass bulb, exhausted by a Sprengel pump to a point where a quarter of an inch spark from an induction coil would not pass between points one millimeter apart (for lack of any air as a conductor) was placed a spiral, the connected wires passing through the glass. The spiral was kept at the most dazzling incandescence for hours without the slightest deposit becoming visible."

So far as securing the light was concerned, Edison had succeeded, and the platinum filament lamp was a success. There was, however, one grave difficulty. This was the all too familiar fact that the melting point of the wire was so slightly above the incandescent point that a very slight increase in the current melted the wire and destroyed the lamp. For some time, thereafter, Edison devoted himself to patents and inventions for the prevention of this undesired sudden increase of the current. Of these he pinned his faith to two: a regulating bar which expanded when the current was too strong, its expansion operating a mechanism which cut off the flow of electricity, and a diaphragm acted upon by the expansion of air or gas inclosed in a tube.

So important, however, had Edison's position in the electrical world become, that just as soon

as the patents covering the platinum lamps and the two forms of regulators were made public, the scientific press of the world took up a discussion of the value of his inventions. It was a unit in declaring that the main weakness of the device lay in the narrow margin between the luminosity of the light and the melting point of the wire, and they pointed out that the adjustments of the regulator would have to be so minute as to render the lamp commercially of doubtful success.

It was a just criticism, but it had been anticipated by Edison. Between the time he had sent in the application to the Patent Office and the day it was given out to the public, the inventor had come to the conclusion that pure platinum never could be suitable to the purpose of electric lighting. By the time the discussion was under way, he was already working on the incorporation with platinum of a non-conducting material. This worked admirably — for a while. But permanence did not lie in that direction. Another series of experiments followed, with various plans for combining conducting and non-conducting materials. As fast as difficulties appeared in these, efforts were made to overcome them by new forms of regulators. At least a

score of regulators were invented to fit special needs, and patented, all to be abandoned.

Thirteen months of never-ceasing investigation, day after day, and often far into the night, had passed. Edison, with that courageous facing of an issue which is so largely part of the secret of his make-up, resolutely came to the conclusion that he was absolutely on the wrong track. He had given his mind to the subject of metals for a year. To the inventor's mind the principle remained sound, though the substance was as yet unthought of.

The clew, though no one but Edison would recognize it as a clew, came largely as an accident. Not only would no one but Edison have seen the clew, none but an Edison could have made use of it. In spite of all the many difficulties in the platinum lamp, so profound was public confidence in the "Wizard" that a number of financiers had come together, formed a company, and placed enormous sums of money at the inventor's disposal. It was on these sums that the latter portion of the experimentation was carried out, though all the earlier trials had been done on the inventor's own funds.

Not exactly despondent, but distinctly downhearted as he reviewed the past work and its final

unsatisfactory outcome, Edison sat alone in his laboratory one October evening in 1879 and reviewed in mind every possible known substance in the world which could be substituted for the metal filament. On the table, stained with chemicals, lay a little pile of lampblack mixed with tar with which one of Edison's assistants had been working that day in connection with the carbon telephone transmitter.

With the unconscious physical motions so often occurring when one is immersed in profound thought, Edison reached out his hand and began rolling a pellet of the mixture between finger and thumb. The tar making it tenacious, the pellet rolled out into a fine thread. Looking down at it idly, Edison was struck by its resemblance to a piece of wire.

Anything resembling wire, by a natural association of ideas, reminded him of the filament needed for his lamp. Of late his mind had been turned to threads of non-conducting materials, and like a flash there recurred to him Starr's experiments on a carbon filament. Being carbon, the lampblack would have a greater resistance than the metal. Could this be a possible solution? Starr's plans had failed utterly, his carbon plates in a Torricellian vacuum burning out rapidly.

Edison, alone, of all men in the world, was in a position to take advantage of the clew. His experiments with platinum had all tended toward the production of an almost perfect vacuum bulb, a bulb in which only one-millionth part of an atmosphere was left behind. This bulb, itself, was the result of Edison's inventiveness, as in his platinum researches he had invented and patented several improvements on the Spreckel mercury air-pump.

A vacuum of such extreme character had never been known before, and a better opportunity to test the properties of a carbon filament had never been before. A thread of the lampblack and tar was inserted in a bulb, the air exhausted, and the current turned on. A good light was the result. But — there was always this "but" in those early experiments — the carbon soon burnt out.

Here was a new problem. The carbon had not burnt out, as the metal did, because of any melting; it must be due to the action of the air. Since the vacuum was almost perfect, the air must be in the lampblack. Edison felt sure that he was on the right track. A carbon filament was needed, but not a filament composed of lampblack and tar.

Then came the historic three days in electric lighting, ending October 21, 1879. Edison, rapidly

thinking over possible materials to carbonize, realized that cotton was specially prepared and spun to be as strong as possible in proportion to its fineness. He sent a boy out for a spool of cotton. Even Charles Bachelor, his closest associate, pinned little hope to the plan. How could so weak a thing resist the force of a current that would melt the hardest of metals?

A loop of the thread, about two inches long, was laid in a nickel mold, clamped and placed in a muffle furnace, where it was left for five hours. It was then taken out and allowed to cool. Next, the mold was opened and the carbonized thread taken out. It broke to pieces at the lightest touch. Another piece of cotton was carbonized and it broke the same way.

For two days and two nights, without rest or sleep, Edison and Bachelor worked on this one experiment alone Two whole spools of thread were used, in two-inch pieces; from this one may realize how many hundreds of disappointments lay in this one heartbreaking series of tests. Only twice in all that time did they succeed in taking from the mold a perfect and unbroken filament, but when they attempted to attach it to the conducting wire, it broke. Another, which showed good signs of strength, was shattered when Bachelor

breathed in its direction. All through the experiments, every time either man breathed, he turned his face away from the thread lest the slight current of air should shatter it.

Bachelor was extraordinarily deft and delicate with his hands, and a third carbon was made and successfully inserted in the lamp. The air was exhausted and the current turned on. As the current flowed through the carbonized bit of cotton thread, it began to glow with a soft light.

In what was little less than an agony of expectation, Edison and Bachelor watched the thread burn. Second after second, minute after minute passed, and the thin filament glowed on steadily. Little by little the current was increased until there was force sufficient to have melted the platinum. But the little carbonized cotton thread burned on. It was still burning, when, after his session of three days and nights, Edison went to bed. It was still burning, when, twenty-three hours later, he got up. It burned for forty-five hours. The problem of electric lighting was solved.

In spite of this success, forty-five hours was too short a time for full commercial satisfaction, and it was at this point that the extraordinarily American character of Edison's genius reappeared. He had solved the problem, the invention was achieved.

But the cost of making bulbs of carbonized thread would be so great, their destructibility would be so easy, and the length of time which they burned so short, that while electric lighting was assured, it would be more expensive than gas and therefore could not enter the field as an equal competitor. The scientific solution of the incandescent light problem was the carbon filament in a high vacuum, the commercial problem was the making of a carbon filament which would be less destructible.

The next two weeks at the Edison laboratory can only be called an orgy of carbonizing. Every available man was set at work turning into carbon every available material. Straw, hay, wicker, paper, cardboard (which worked very well), splints of every kind of wood, all were called into requisition. No walking-stick or umbrella was safe. It was Edison himself who made the next step. He got hold of an old bamboo fan and carbonized different parts of it. The rim that went round the edge of the fan, when carbonized, proved to make by far the best filament that had yet been tried.

The inventor took up the question of bamboos. He found that botanists had listed twelve hundred varieties of bamboo, in various parts of the world, many of them in inaccessible jungles and forests.

It took Edison about one minute to decide that he wanted samples of every kind of bamboo in the world. He sent out half a dozen men to rake every corner of the globe for bamboo. The search cost more than $100,000.

Nothing is more characteristic of Edison than his persistence in trying everything. The carbon filament is an astonishing example of this. The story of how he sent James Ricalton is worth telling. Ricalton was principal of a school at Maplewood, New Jersey, and was a student of natural history, having written a few scientific papers which showed him to be a keen field observer. Edison sent for him, and without any preliminaries began the interview:

"I want a man to ransack all the tropical jungles of the East to find a better fiber for my lamp; I expect it to be found in the palm or bamboo family. How would you like that job?"

"It would suit me," Ricalton replied.

"Can you go to-morrow?"

"Certainly, but I must arrange for a substitute. Maybe I can do that to-night. Can you tell me how long the trip will take?"

"How can I tell?" responded Edison. "Maybe six months and maybe five years; no matter how long, find it."

More than a year later Ricalton returned after a trip full of the most amazing experiences. He brought back over a hundred species of bamboo, two of which proved more successful than any so far found. On the day of his return he met Edison in the hall of the laboratory. The inventor recognized him, shook hands, and said,

"Did you find it?"

"Yes," Ricalton replied.

"Good!" Edison responded and passed on, troubling himself no further about a great expense and a marvelous effort, which, a few weeks later, was to prove futile and be superseded by a better fiber.

One of the best samples of bamboo was secured in Japan in 1880 by W. H. Moore, and in 1880 an expedition was organized to hunt through the interior of Brazil. Other men went to the West Indies, to British Guiana, Mexico, Ceylon and India. In 1887 McGowan led an expedition up the Amazon and secured a fiber still better than anything that had gone before. The mere story of McGowan's adventures is perhaps the most thrilling narrative in the whole history of quests for the sake of science.

Yet the ideal and perfect bamboo seemed as hard to find as the Fountain of Perpetual Youth,

or the Golden El Dorado. After these years of search Edison adopted a compound carbon filament, which could be manufactured on a large scale, and which, in its turn, has given place to tungsten filament and nitrogen lights.

CHAPTER IX

The Power behind the Bulb

The perfection of the electric light bulb solved the question of electric lighting, as scientifically considered, and the various improvements that Edison made in the bulb gradually increased its length of life and decreased its cost, so that it became possible to enter the new light as a competitor with gas. But here another difficulty was encountered. Gas was an established industry, with its own mains and street franchises. The electric light bulb was only of value when it could be attached to an electric current. If electricity were to supplant gas, or even to supplement gas, it was imperative that there should be central electric stations in cities.

Edison laid the foundation of this by preparing a general illumination of Menlo Park, where his laboratories were at that time. During the early days of January, 1881, a special illumination took place for the edification of the New York Board of Aldermen, who took a special train to the inventor's

works. It had been so arranged that the party should arrive after dark, and the hundreds of incandescent lamps glowing among the leafless trees was a striking example of the success of the Edison electric light.

One of the features which attracted special attention was the fact that each lamp could be lighted or extinguished independently. Realizing the importance of this visit, and desiring to insure against possible failure, Edison had put in fine copper wire as fuses in various places. It was well that he did so, for one of the aldermen, either as a joke or with ulterior motives, had brought along a piece of heavy wire, hidden up his sleeve. He managed to short-circuit the mains with his wire, and was very much surprised because only three lamps went out.

A similar occurrence happened when a Baltimore committee was on a trip to report on the light. This time the miscreant was caught by the special watchers that Edison had appointed. When searched, a piece of insulated No. 10 wire was found running up his sleeves and over his shoulders. In this case, four lamps went out. They found that he had an interest in the Baltimore Gas Co. The Baltimoreans were shocked, and the principal effect was to set them against

the Gas Company and to align them in favor of the electric light.

The visiting committees from various cities usually returned greatly impressed with the efficiency of the system and ready to listen to any reasonable plan that was laid before them dealing with electric light. As Edison had hoped, these trips enabled the men forming the committees to deal with electrical matters with an intelligent understanding.

When the time came to approach the problem, Edison was ready. Together with his plans for the perfecting of the incandescent bulb itself, his mind had been busy with the still vaster question — that of the establishment of a great central station from which consumers might obtain their electric light in the same way that they did their gas. For, after all, the electric light bulb was to an electric system no more than a gas jet is to a gas lighting system.

Here is an even greater example of the character of Edison's work. The commercialization of his invention in such a way that the world should be benefited was his ambition, the mere scientific satisfaction was not enough for him.

It must be remembered that electric lighting was something entirely new. Aside from the

string of lamps that shone down the walk at Menlo Park, there was not another in the world. No factories existed where apparatus could be made, and there were no trained men to supervise, to construct, or to install an electric light system. Indeed, outside the Edison laboratory there was no one who knew anything about electric lighting. Not only did Edison have to make the plant, he actually had to teach everybody everything connected with it.

In typical fashion, the inventor sent for a large insurance map of New York in which every elevator shaft and boiler and housetop and fire-wall was set out. After careful study, he decided that a section of the city which embraced the larger number of the financial and office buildings, and which extended from one river to the other, was the best for his purpose.

The first point was to find out how much gas was used. Edison hired men to tramp certain beats in that district every hour of the night, counting, on each round, the number of lights burning. Knowing the price of gas and the average consumption per burner, Edison got a rough idea of what the people of that district spent for gas. After a little close figuring, he decided that he could afford to give them elec-

tricity at a price sufficiently close to gas to warrant him in proceeding.

But when it came to building the central station and installing the system, Edison had his hands full. One of his men was put in charge of a factory for making the lamps, another was set to work making tubes, a third got hold of a machine shop and started making the dynamos, while others, again, undertook various needed small parts. Real estate was almost impossible to get, but at last Edison secured a place. It was far too small, and a huge output was needed. The only way out of the difficulty was high-speed engines — and — there were no high-speed engines in those days. Edison, in the *Engineering Review*, has told how he overcame the difficulty.

"I had conceived the idea of a direct-coupled machine and wanted to hitch the dynamo direct to the engine without belting," he wrote. "I could not see why, if a locomotive could run on that speed, a 150 horse-power engine could not be made to run 350 turns a minute. The engine builders, when I asked them about it, held up their hands and said 'Impossible!' I didn't think so. I found C. H. Porter and said to him,

"'Mr. Porter, I want a 150 horse-power engine to run 700 revolutions a minute.'

"He hummed and hawed a bit and then agreed to build it. After a while, he got it finished and sent it out to the Park. We set the machine up in the old shop, and I had some idea of what might happen. So we tied a chain round the throttle and ran it out through a window into the wood-shed, where we stood to work it. Now the old shop stood on one of those New Jersey shale hills, and every time we opened up the engine and she got to about 300 revolutions, the whole hill shook under her. We shut her off and rebalanced, and tried again, and, after a good deal of trouble, we finally did run up to 700, but you should have seen her run! Why, every time the connecting rod went up, she tried to lift that whole hill with her! After we got through with this business we tamed her down to 350 revolutions (which was all I wanted). . . . We closed a bill with Porter for six engines.

"While all this was going on in the shop, we had dug ditches and laid mains all around the district. I used to sleep nights on piles of pipes in the station, and I saw every box poured and every connection made on the whole job. I had to! There was nobody else who could superintend it. Finally we got our feeders all down and started to put on an engine and turn over one of

the machines to see how things were. My heart was in my mouth at first, but everything worked all right and we had more than 500 ohms insulation resistance. Then we started another engine and threw them in parallel.

"Of all the circuses since Adam was born, we had the worst then. One engine would stop, and the other would run up to about a thousand revolutions and then they would see-saw.

"What was the matter? Why, it was these Porter governors! When the circus commenced, the men who were standing round ran out precipitately, and some of them kept running for a block or two. I grabbed the throttle of one engine, and E. H. Johnson, who was the only one present who kept his wits, caught hold of the other and we shut them off. Of course I discovered then that what had happened was that one set was running the other one as a motor.

"I then put up a long shaft connecting all the governors together, and thought this would certainly cure the trouble, but it didn't. The torsion of the shaft was so great that one governor managed still to get ahead of the others. Then I got a piece of shafting and a tube in which it fitted. I twisted the shaft one way and the tube the other, as far as I could, and pinned them

together. In this way, by straining the whole outfit up to its elastic limit in opposite directions, the torsion was practically eliminated, and after that the governors ran together all right.

"Somewhere about that time I got hold of Gardiner C. Sims, and he undertook to build an engine to run at 350 revolutions and give 175 horse power. He went back to Providence and set to work and brought the engine back with him. It worked, but only for a few minutes, when it busted. That man sat around that shop and slept in it for three weeks until he got his engine right and made it work the way he wanted it to.

"When he reached this period, I gave orders for the works to run night and day until we got enough engines, and when all was ready, we started the main engine. The date was September 4, 1882, a Saturday night. That was when we first turned the current on to the mains for regular light distribution, and it stayed on for eight years with only one insignificant stoppage. One of these engines that Sims built ran twenty-four hours a day for 365 days before it was stopped to give it a rest."

The first incandescent electric light central station in the world was at Appleton, Wisconsin, with one dynamo and fifty lights. From that time to the present, the industry has grown to

such an extent that figures scarcely serve to show its rate of growth. Thirty years after its invention, the investment in the electric lighting plants of the United States was estimated at a billion dollars and that of foreign countries together as three billion dollars. The day is close at hand when half a trillion dollars will be invested in the invention whose perfection can be unhesitatingly ascribed to Edison alone.

At this point it is well to clear up the old and much disputed question as to the amount of originality and creativeness displayed by Edison in this invention of the electric light, his greatest success. In the first place it must be made clear that Edison does not consider himself as the discoverer nor the creator of the incandescent electric light. He does claim, and in this the courts have upheld him, that he alone succeeded in bringing into harmonious application many ideas which had been commercially valueless when separated.

The electric light bulb was used in 1845 by King, in 1846 by Greener, and by many inventors prior to the patents of Edison. Yet none of these had succeeded in getting an electric bulb with as high a vacuum as Edison. Nor could they have done so, for Edison himself invented many improvements to the mercury pump for exhausting the

bulbs. Edison's work on air-pumps, therefore, was essential to the success of the electric light bulb. In a way, this is the first step. Greener's bulb was true in principle but defective in operation. It could not be made effective except by improvement. Sprengel's pump was true in principle but not sufficiently exact. Edison improved Sprengel's pump, then directed the improved pump to the old principle of Greener's bulb. Here is no discovery, but true invention, and invention directed exclusively upon the line of efficiency.

Almost the same condition prevails with regard to the use of the carbon filament. No one would deny, Edison least of all, that Starr and others had used a carbon pencil in a partial vacuum. But though, in the Goebel, the Sawyer-Mann and other cases, the earlier examples of carbon filament lamps were brought up, the fact remained that they had not been made effective. Goebel went so far as to claim that he had even discovered the superiority of bamboo before 1872, but the courts ruled the evidence out as inconclusive. The point again, is not the discovery of the carbon filament, but the inventive development which little by little laid the ghosts of failure and which transformed a toy of the laboratory into a boon to the human race.

Still further is Edison to be remembered as a master electrical engineer. The story of the electric light is not alone the story of the vacuum bulb and of the carbon filament, it is the story of the Central Station. It is the story of the manipulator of plans to bring daylight into a city's streets. It is the development which enables coal mines to be lighted without the fear of explosion. It is the story which has made fire at sea an infrequent occurrence. For Edison, first, last, and all the time, has set before himself the task of utilizing to their greatest capacity the forces he has developed.

There are few more illuminating things than Edison's own point of view on such matters. To him a discovery is a "scratch"; he always calls it so. Almost any clever man, he is wont to say, might discover something. But to take that "scratch," to see the potentialities that lie within it, to fix upon a distant goal which to others seems beyond attainment, and to work persistently, patiently, untiringly for that goal, overcoming every obstacle by working first in this direction, then in that, this, to him, is invention.

Edison's "twelve-million dollar brain" is a phrase that became popular when the four leading Edison companies were consolidated into one con-

cern, known as the General Electric Company, with a capitalization of twelve million dollars. As a matter of fact, the inventions that have proceeded from Edison have been worth vastly more than twelve million dollars to the world.

Yet, when the entire question of electric lighting is analyzed, it is clear that two forces and two forces alone have contributed to Edison's success. Each of these is within the reach of almost every intelligent boy. These are — the perception of values, and hard work. It is of no use to perceive the value of doing a thing unless one works hard at it, and it is of no use working hard at a thing unless it is worth the doing.

This test can be applied universally to Edison's work. There is no case on record in his whole life when he devoted his time to an object that lacked practical usefulness, and there is no one thing which he deems to be of immediate practical need on which he has not worked hard. He has not always succeeded, but that is merely to say that he is not infallible.

CHAPTER X

Making a Shrine for Speech

While the electric light is undoubtedly Edison's greatest gift to mankind, his most unique one is the phonograph. The earlier claimants to the proud title of "Father of the Telephone" were two Frenchmen, Edouard-Leon Scott de Martinville, who in 1857 invented a "phonautograph," and Charles Cros, who in 1877 invented an instrument which his friend the Abbé Leblanc called — creating the word — the "phonograph."

Scott's device was of the crudest, though he succeeded in causing his phonautograph to render back faint sounds from the blast of two huge organ pipes, three feet from the instrument. But Cros' phonograph was far more scientific. Its main, and utter, difference from Edison's invention was that instead of depending on indentations in a soft substance which might be hardened, it was based on the wavings of a line which an index finger would make if attached to a diaphragm caused to vibrate by the sound-waves of the voice.

As compared with these two early ideas, Edison's is entirely original. This invention of his was born with him absolutely. He is the discoverer as well as the inventor, and to his constant work in its improvement, the phonograph has come to be the almost perfect instrument of to-day.

The phonograph was not due to any happy accident. It was not even a quick idea born from a sudden thought. It came to its inventor as a flash, indeed, but only after long thought along that very line and during experimentation on a line that was closely parallel.

It is well to emphasize this. Many inventors — especially young ones — are likely to think of inventions as "lucky ideas that happen to strike it right." There are very few of these in the history of invention. As has been said before, an inventor has got to know his field before he can be sure whether an idea is of any value, and he has to work like a slave to perfect the idea.

One more point may be made which illustrates Edison's extraordinary genius. It is that he never fritters away time. He never wastes time on something which is merely interesting, as long as there is something of value to be done in perfecting matters which have already shown themselves to be of value to mankind.

"What's the use?" he answered a visitor one day, when his caller was speaking of the vast possibilities as yet unexplored, that occur as suggestions here and there in his volumes of "Notion Books." "What's the use?" he repeated. "One lifetime is too short, and I am busy every day improving essential parts of my established industries."

There are thousands of patents in the Patent Office which would bring fame and fortune to their inventors, if the men who had devised them had given as much time to their application to industry as they did to their invention. Not more than one quarter of Edison's life has been spent in actually inventing new devices, the other three-quarters has gone in industrializing them. The value of an invention does not lie in what it is itself, but in what it is made to do.

In just such a way, the phonograph found its real beginning in the fact that Edison noticed a humming sound coming from a model he had made while experimenting on the automatic telegraph. He paid no especial attention to it at the time, but, like all subsidiary events occurring during experiment, it sank into his memory, unconsciously.

As it so happened, the telephone question became of supreme importance a few days later, and Edi-

son was unable to proceed with the modification of the automatic telegraph. It was not until years later that, with the telephone puzzles solved, he returned to the automatic telegraph, his desire being to invent a machine which would repeat Morse characters that had been recorded on paper by indentations. The main idea was that this indented paper should pass under a tracing point. This point was connected with an increaser, which multiplied its movements, and this again was connected with a telegraph-sending apparatus. By this means, a message received at a given office could be relayed and transmitted automatically.

In returning to his manipulation of this machine, Edison found that, when the cylinder carrying the indented paper was turned quickly, it gave out a sort of humming noise. Immediately he remembered a somewhat similar experience on an earlier model.

Edison, in some ways, is quite hard of hearing, but to other sounds he is extraordinarily susceptible, and one of these is Morse. It seemed to him, then, he since has said, that the humming noise sounded like Morse heard indistinctly. The multiplication of small sounds to great ones has always been a pet hobby of Edison's, and it occurred to him that this humming could be intensified. Here

was the second clew, which also registered itself in the inventor's mind, and then lay dormant.

In Dickson's "Edison," the inventor is quoted as giving the third and the more immediate cause of the direction of his attention to the phonograph. The statement is reported as follows:

"I was singing to the mouth-piece of a telephone," Edison is quoted as saying, "when the vibrations of the voice sent the fine steel point into my finger. That set me thinking. If I could record the actions of the point and send the point over the same surface afterwards, I saw no reason why the thing would not talk. I tried the experiment first on a strip of telegraph paper. I shouted the words 'Hello! Hello!' into the mouthpiece, ran the paper back over the steel point, and heard a faint 'Hello! Hello!' in return. I determined to make a machine that would work accurately, and gave my assistants instructions, telling them what I had discovered. They laughed at me. That's the whole story. The phonograph is the result of the pricking of a finger."

The statement, as quoted, is interesting and modest, but it conveys an entirely false impression. It suggests a discovery that was more or less of a "fluke." Yet it was nothing of the kind. Edison had been experimenting for years on the

telephone; he knew as much about sound waves and voice vibrations as he did about electricity, and he had already done some preparatory work on the microphone. The question of voice vibrations on a diaphragm was one to which he had given years of thought, and he could instantly tell the amount of vibration that any given vowel or consonantal sound would give to a diaphragm of any given substance.

When, therefore, Edison attached a diaphragm to the machine in order to record the sounds, and when he spoke against that diaphragm, he was following a clear line of reasoning. When to this diaphragm he attached a mechanism which would multiply the vibration sufficiently to indent a given material, and when he selected paraffined paper as this material, every step was the result of a logical process.

The inventor sent for Krusei, the best of his early model-makers, gave him a rough sketch of the idea, and told him to make one. It is of interest to know that the price Krusei charged was eight dollars and that it took him thirty hours without sleep to build it. At the end of that time he brought the first actual working phonograph into the world, a clumsy-looking affair, now in the Victoria and Albert Museum, in London.

Carman, the foreman of the machine shop, was present when Krusei brought in the model. On being told what it was for, he declared it impossible, and bluntly bet Edison a box of cigars that it wouldn't work. With a slow smile, Edison took the bet; then, sliding the model along the table in front of him, he turned the crank slowly, speaking into the receiver the first verse of the child-rhyme, "Mary had a little lamb."

The cylinder was returned to the starting point again and the handle turned once more. Then, very faintly, but still unmistakably, came back, "Ma'y 'ad .. 'it' 'am," with a reminiscent hint of "his Master's voice" in it. This extraordinary success with a first model, this first phonograph in history, was ushered into the world to the accompaniment of a disgusted remark from the foreman, "Well, I guess I've lost again!"

So far, so good, but when it came to perfecting the phonograph, the difficulties were great. Developing, as it did, mainly along the lines of pleasure-giving, it was necessary that the phonograph should attain a high standard of perfection. The actual machinery gave little trouble — indeed, the phonograph is one of the simplest mechanisms possible — but the records were another matter.

The tinfoil, although it had served its purpose faithfully and efficiently, proved worthless as a recorder. It did not retain the impression accurately, and after being used once or twice, was useless. Edison turned his attention to some other substance, wax naturally suggesting itself to him as the best.

The securing of wax for the records was another case similar to that of filaments for the electric light. Edison bought every book that dealt with animal or vegetable fats — even in the most remote way — and studied them all. He sent for samples of every known fat in the two hemispheres. He set at work the best men in his staff, blending, mixing, and testing hundreds of varieties; he engaged special chemists; and at last he secured a combination of waxes that answered his purpose. From this, excellent records were made.

In Dyer & Martin's "Life of Edison," the inventor is quoted as giving the story of how the marvel of enshrining the voice was first given to the world.

"That morning," the account reads, "I took it [the newborn phonograph] over to New York, walked into the office of the *Scientific American*, went up to Mr. Beach's desk, and said I had something to show him. He asked what it was.

I told him that I had a machine which would record and reproduce the human voice.

"I opened the package, set up the machine, and recited 'Mary had a little lamb,' etc. Then I reproduced it so that it could be heard all over the room. They kept me at it until the crowd got so great that Mr. Beach was afraid the floor would collapse.

"The papers, next morning, contained columns about it. None of the writers seemed to understand how it was done. I tried to explain it to them, it was so very simple, but the results were so surprising that the reporters made up their minds probably that they never would understand it — and they didn't.

"For a long time some people thought there was trickery. One morning at Menlo Park a gentleman came to the laboratory and asked to see the phonograph. It was Bishop Vincent . . . I exhibited it, and then he asked if he could speak a few words. I put on a fresh foil (this was in the days when the wax was as yet in the experimental stage) and told him to go ahead. He commenced to recite Biblical names with immense rapidity. On reproducing it, he said, 'I am satisfied now. There isn't a man in the United States but myself who could recite those names with the same rapidity.'"

But instead of being a piece of claptrap, or even a nine-days'-wonder, the phonograph advanced with giant strides. In Europe it was widely exhibited, men of science and royalty vying with each other in their eagerness to hear the marvelous invention. The Paris Exposition of 1889 confirmed the triumph of Edison in Europe. Forty thousand people a day flocked to hear the phonograph. Its success was complete.

Again the situation may be compared to that of the electric light. The perfect phonograph record, like the perfect light, had been secured. But it was costly and it was fragile. Edison, who never lets go a thing until it is put on a practical basis, tried every device, even making the cylinders of thin paper with an eighth of an inch covering of wax. This reduced their cost but increased their fragility, and considerable care had to be taken in handling them.

The public is not careful, and an article which is to be much used has got to withstand a certain amount of rough usage. Since every kind of wax had been tested, Edison discarded wax and tried stearate of soda. It was the solution of all his difficulties. From that time on, numerous changes have been made in phonograph records, the chemical composition of them has varied from time to

WHAT MAKES A PHONOGRAPH SING

Part of a phonograph record, seen through a powerful microscope. The difference in the curves shows the different notes, and in the shapes of the curves the different sounds of that note or of a voice. When the needle passes over these points, it vibrates in exactly the manner that the curve has been made.

time, but the principle remains unswervingly the same.

The principle of the phonograph being early established, Edison turned his attention to the electric light, and for several years little was done on the voice-recorder. Its perfecting and its introduction as a commercial asset, therefore, date after the incandescent light. Though born first, its maturity was delayed.

One of the main reasons of delay was the phonograph's seemingly incurable habit of lisping. Thousands, yes, tens of thousands of records were made of "Mary had a little lamb, *lamb*, LAMB, LAMB," and not a few of them are decorated with such following sentences as, "You gol-swingled beast, can't you say LAMB!" Another word of which the very walls of the old buildings must have got tired was the word "Spezia," used innumerable times in an effort to educate those early phonographs to distinguish between the two sounds of 's,' and to say a 'p' properly.

The inventor's conceptions of the various uses to which the phonograph would be put are of considerable interest, as showing the ends he sought and as compared with the actual development that has occurred in the nearly forty years

since the first phonograph patent was secured. In the *North American Review* in 1878, he wrote:

"Among the many uses to which the phonograph will be applied are the following:

"1. Letter-writing and all kinds of dictation without the aid of a stenographer.

"2. Phonographic books which will speak to blind people without effort on their part.

"3. The teaching of elocution.

"4. The reproduction of music.

"5. The Family Record (a registry of sayings, reminiscences, etc., by members of a family, in their own voices), and of the last words of dying persons.

"6. Music boxes and toys.

"7. Clocks that should announce, in articulate speech, the time for going home, time for meals, etc.

"8. The preservation of languages by exact reproduction of the manner of pronouncing.

"9. Educational purposes, such as preserving the explanations made by a teacher, so that the pupil can refer to them at any moment; and spelling or other lessons placed upon the phonograph for convenience in committing to memory

"10. Connection with the telephone, so as to make that instrument an auxiliary in the transmission of permanent and invaluable records,

instead of being the recipient of momentary and fleeting communication."

The year 1888 was phonograph year. The Patent Office, in that one year alone, granted Edison thirty patents on improvements connected with the phonograph. The wax had been substituted for the foil, a sapphire point had taken the place of the steel pencil, and the reproducing "needles" had become exceedingly fine, globe-pointed devices.

From the exceedingly fine details required in the phonograph, where indentations one-thousandth part of an inch make all the difference between the various tone qualities of a singing voice, Edison's attention turned to matters on a large scale. His next years of effort were given to his great magnetic ore separator. This was an example of a perfect principle, perfectly applied, brought to perfection by Edison, to which he gave five years of constant thought and attention, and which ended in a tremendous monetary loss. To a smaller man, the result would have been nothing less than utter ruin, but Edison's only comment was,

"Well, the money's all gone, but we had a whale of a good time spending it."

The origin of Edison's connection with the magnetic ore separator is stated to be the washing

in of a patch of blackish sand on the seabeach at Quogue, L.I. As it is an unfailing rule of Edison's life never to pass a new thing, and always to bring to his great storehouse every available substance, the "Wizard" filled his pockets with the sand.

When, a few days later, he returned to the laboratory, thrusting his hand into his pocket, he found the sand, which he promptly emptied out upon the laboratory table. On this table there chanced to be a magnet lying, and as the sand poured near the magnet, a number of the little black grains were attracted to it. Edison at once saw that the magnet separated the magnetic from the non-magnetic particles, and his mind jumped to the possibility of using this in practical milling of low-grade ores, or ores in which the proportion of valuable and magnetic material is small.

The idea was not precisely new, as, in the seventeenth century, Gilbert, that extraordinary scientist of Queen Elizabeth's court, suggested that the magnet could be used for "separating the pure from the impure," as he phrased it. But Gilbert's prophecy had nothing to do with Edison's planning. The metallic sand lay before him. Obviously, if ore could be crushed into particles as small as that sand, they could be separated. Or, if the

magnet were larger and more powerful, the particles need not be quite so small. There was the principle; the working of it out was only a matter of experiment.

Unfortunately for the inventor, this was not the sort of thing which could be carried out on a small scale. Innumerable laboratory tests were made, ores were shipped in from all parts of the world, crushers were made with magnets in proportion to their size. Certain ores were found more or less refractory, but still all of them could be brought into their proper relations. The laboratory test was conclusive, the problem was solved, and hundreds of millions of tons of metalliferous rocks, which had been deemed too low-grade for mining, immediately became available.

Had Edison stopped there, had he taken out patents on his inventions and the ideas for machinery connected with it, he would have been the richer by half a million dollars and the world would have gained almost five years of the inventor's time. But Edison, in his characteristic way, wished to establish his invention as a commercial industry. He had done this with the electric light, he had done this with his duplex telegraph, while other of his inventions he had sold in such a way that they were commercially gainful, and he

desired to place his magnetic milling on the same basis of advantage.

With his accustomed concentration, Edison set his mind resolutely to the problem. No machinery existed which contemplated the crushing of the hardest rocks to powder, and the inventor had to plan all these. A few of the devices were machines in general use carried to a finer scale; some were modifications of existing machines; but the string of patents taken out in Edison's name in connection with ore-milling machinery shows to how large an extent his inventive powers were devoted to this end alone. Under his fertile mechanical planning, a marvelous metallurgical plant was built. A big tract of land in Sullivan County was the scene of operations, and around the milling plant grew up a small town of over two hundred houses. All these were modern, equipped with electric light and conveniences strange to so small a place.

From the inventor's point of view the experiment was thoroughly successful. Scarcely an ore of any consequence was found to fail, and in the five years, practically every detail was finished and every obstacle overcome. But Edison was not fortunate in his commercial appeal. Capital did not pledge itself readily to the work, the ship-

ping facilities to the ore-milling plant were poor, and the organization necessary to extend the new metallurgical system throughout the country would have taken all of Edison's time. It would have made a good life work for most men, but Edison's brain was too multifold for him to remain perpetually at milling. One day he closed down the mine.

No one lives now at "Edison," and the miners' cottages still stand there, falling into decay. Many of the buildings are in ruins and the machinery has rusted in the pits where it stood. The project, as a business venture, was a failure, but in Australia and in Norway, in the Andes and in the Himalayas, are mines where magnetic ore separators are at work. The "Wizard's" ore works are shut down, but his wizardry continues unbroken.

There is a very decided hint of the combination of stoicism and the love of work which has descended to him from his Dutch ancestry in Edison's comment on the ore-milling work, when years later, telling his reminiscences of that time, he said:

"I never felt better in my life than during the five years I worked there. Hard work, nothing to divert my thoughts, clear air and simple food

made my life very pleasant. We learned a great deal. It will be of benefit to some one some time."

How much of the interpretation of Edison's character lies in that phrase, "We learned a great deal"! To the inventor, then verging toward fifty years of age, the value of five years of painstaking and arduous toil found sufficient reward in the knowledge that "We learned a great deal." It is the clew to his combined simplicity and greatness.

Much of the machinery devised by Edison for the purpose of crushing ore into powder is still used by him in his cement works at Stewartsville, New Jersey. The works cover eight hundred acres of ground.

As a natural sequence to his development of the cement industry, Edison thought of plans whereby concrete might be turned to new uses. Being brought face to face with the high cost of lumber, in connection with the building of one of his plants, he thought of the extension of the use of concrete as a building material. It was a matter to which he returned from time to time, and in odd intervals perfected the plan. It is now possible to "build" an Edison concrete, ten-room house, weather-proof, almost bomb-proof, in four days. A steel mold is made into which the con-

crete is pumped, allowed to harden, and the mold then removed. The window-frames are made in the same way. Hundreds of these houses have been constructed and have proved satisfactory.

Allied in some respects to the idea of the magnetic separation of ores is Edison's invention of the pyro-magnetic motor and the pyro-magnetic generator. Both of these are a modern application of an ancient principle, also mentioned by Gilbert, the "Father of Magnetism," in the seventeenth century; namely, the diminution of the magnetic power in iron when hot. As a matter of fact, after iron is heated slightly above the point of 'cherry' heat, the magnet has no influence on it whatsoever.

In Edison's pyro-magnetic motor, a pivoted bar is heated and cooled by turns, being strongly influenced by the magnet when cold, and unaffected when hot, the alternation giving rise to the rotary motion. Upon the same lines was constructed his pyro-magnetic generator, with the end in view of producing electricity from coal.

Along this latter line of experimentation, Edison's mind has been occupied for several years. He regards it as the most important problem of the age. The great inventor has laid aside many commercial ventures, at times, to concentrate

on this one problem. He has made considerable progress, but not sufficient to justify him in revealing his experiments.

Of the tremendous force hidden in coal, a trifle less than fifteen per cent is used, the remaining eighty-five per cent being wasted. Combustion of coal, especially with the machinery with which it is now used, is, to Edison's economics, wasteful to excess. If electricity could be generated direct from coal, the problem of the world's power would practically be solved, steam would become obsolete, and electricity would reign supreme.

CHAPTER XI

"Movies," and the Storage Battery

Just as the old game of "rounders" is the foundation of the national game of baseball, which fills the thoughts of every American boy and many million American men from spring till fall, so the zoetrope was the forerunner of the moving picture of to-day. But the whole business of "moving pictures" is so large, and requires so many things for its full use, that to no one man can be ascribed its sole origin. It may justly be said, however, that in the ultimate development of the cinematograph and biograph to completeness, Edison's kinetoscope has played an important part.

To Edison, "king of speed" as he has been called, the development of instantaneous photography afforded an opportunity for investigation and experimentation that appealed tremendously to the imaginative side of his nature. He saw how this could be applied to Plateau's "phenakistoscope" of 1833, to the improved zoetrope, invented by Raynaud in 1870, which he called the "praxino-

scope," and especially to Muybridge's "zoöpraxiscope" in 1877.

Edward Muybridge, an American, was the first to apply photography to the zoetrope idea. In 1877 he placed a series of cameras at regular intervals opposite an inclined white reflecting surface. A fine thread was stretched from the shutter of each camera to the screen, and a horse was trotted in front of the battery of cameras. As he trotted along, he broke each of the threads in turn, and these operated the shutters, giving a series of plates showing the horse's posture at the moment of exposure. To project these, Muybridge invented his "zoöpraxiscope," in which the positives, fastened to a large revolving disk, were whirled in succession in front of a "magic" lantern.

It is remarkable that the three men who worked independently on this problem at this time were all naturalists. Just as Muybridge was interested in his "zoöpraxiscope," because his hobby was the horse, so Stephen Marey, of France, adopted a somewhat similar device with a "photographic gun" for studying the flight of birds. Demeny, a pupil of his, used the same device for reproducing the movements of a speaker's lips, so that deaf mutes could read "sentences written by photography."

Anschutz, in Germany, a naturalist of more general range, developed a more improved machine, on the same principle, which he called the "tachyscope." In this the positives were made right on a glass disk. When this was rotated, each picture, as it came before the opening, was lighted by a spark from a vacuum tube, giving a sharp, clear image.

The invention of the celluloid film in place of the old glass plate made true "moving pictures" possible. The "father" of the craft, without much doubt, was W. Friese-Greene of England, who took out a patent in 1882, nine years before the appearance of the Edison kinetoscope. His machine was quite efficient, his patent called for a long strip of celluloid film, and he publicly exhibited moving pictures that had been taken by him.

In going on to show the part that Edison has played in the development of moving pictures, it is necessary to point out the great difference between this invention and every other on which he has worked. In the phonograph, the sound waves received are continuous, in the moving picture camera and projector the light waves are discontinuous, or made of a series of pictures thrown on a screen in rapid succession.

This is only possible because the human eye needs to see a certain scene for a given length of time before it really is perceived. This is known as "persistence of vision." An impression received by the eye cannot be instantly replaced by another, but will remain for one twenty-fourth part of a second, and will gradually fade out, being quite obliterated, after another twenty-fourth part of a second, or it will persist for one twelfth of a second in all. For example, if we were looking at the piston of an engine at rest, and it darted out and in to the same point of rest, its entire movement being performed in less than the twenty-fourth part of a second, we could not have seen it move at all. A fly's wings beat more rapidly than twenty-four times a second, consequently we never perceive them, we only see a blur. A bird's wings beat less rapidly than this period of persistence of vision, and therefore we can see them flutter.

If, therefore, pictures can be thrown on a screen in front of the eye so quickly that the change comes in less than this twelfth part of a second, it is impossible for us to see the change. Moving pictures are projected at the rate of a fifteenth of a second. This gives time for the picture to be seen, for the fraction of a second's eclipse between

one picture and the next, and for the second picture to appear before the impression of the first is gone. As the second picture fits over the first, with an incredibly small change, it appears to the eye as moving.

With the combined discovery of the gelatine-bromide sensitive preparation, and the celluloid film, it was possible to take pictures with great rapidity. When, late in the eighties, Edison turned his attention to the question of the kinetoscope, he knew nothing whatever about photography. Even for amusement he had never taken a snapshot, never developed a plate. But no sooner did he get started on the idea of reproducing movement as he had reproduced sound, than he saw that he must master photography if he would succeed. He worked early and late, his fondness for chemistry aiding him greatly in the technicalities of sensitive preparations for photographic plates.

In order to secure absolute efficiency, Edison realized that the pictures would have to be taken exceedingly rapidly, about fifty a second, if they were to seem life-like and if there was to be avoidance of jerking when thrown on a screen. This required a camera with an action rapid enough to operate the shutter and to move the film, and

also a film sensitive enough to light to receive a brilliant impression in one fiftieth of a second.

None of the films in the market were satisfactory to Edison, indeed, none of them could do precisely what he wanted. Accordingly he opened a photographic laboratory, and after a series of experiments as costly as they were exhausting, he succeeded in getting films sufficiently rapid for his purpose.

The details of the mechanism of the taking camera and the projector troubled the inventor but little; fertile expedients always suggested themselves readily to him, and the perfected kinetoscope in 1891 was the result. In his characteristic way, Edison thought mainly of the kinetoscope on a larger basis. He saw its value for educational purposes, and its great mission as a recorder of important events.

In April, 1895, Lumière in Paris, and Acres in London, produced machines which were practical in every way, yet which had distinct features of their own. The quick French mind saw the possibilities of the cinematograph, as it was there called, and the frugal French mind realized that a vast amount of amusement could be secured for a few sous. With what can be described as nothing less than a whirlwind of approval, the

moving picture swept through France, and through Italy, a scarcely less rapid development proceeding in England meanwhile.

Edison, thinking more of the perfection of the kinetoscope than merely of making films which would sell, continued his work at Orange, New Jersey, and patent after patent was filed by him, covering more and ever more improvements on the kinetoscope. It was a race between Europe and America; and when at last the European "movie" companies entered the United States, they found the Edison kinetoscope fully established.

So huge were the proportions to which the business grew, that Edison, satisfied with his work in laying a sure foundation for the great new art of the photo-drama, kept his studios at work supplying high-class films for the commercial exchanges, and turned to other features of the work.

The inventor believed for some years — indeed still believes — that the phonograph and the kinetoscope should be allied. In 1907 he predicted that the time was not far distant when Grand Opera would be given by a combined phonograph and moving picture so completely paralleling actual performance that it would deceive good critics. Many public performances with the "phonocinematograph" were given be-

tween 1910 and 1912, but absolute exactness of register was difficult to obtain.

There were two main obstacles, or "bugs," as the inventor calls them. The first of these was in the recording, the second in the projecting. In the recording, it was found that the moving picture camera recorded the actions of the performers before the sound of their voices reached the phonograph. This was, firstly, because light travels more quickly than sound, and secondly, because the chemical action of light on a sensitive plate is faster than the mechanical action of sound-waves on a diaphragm.

So when the villain says, "Be mine or you shall die!" stabs the heroine, and jumps over the castle wall, it is disturbing to have him jump over the castle wall before he has said anything to the heroine. What was more, certain vowel sounds registered quickly, others more slowly, so that speeding the phonograph a little ahead of the projector (which was tried) failed to produce the required result.

The second difficulty was that of making the phonograph reproduction and the moving picture operate in exact harmony. The phonograph had to be on the stage so that the voices might seem to come from the pictured actors, the projector

had to be at the back of the theater so that the pictures could be projected on the screen. Minor difficulties of synchronization became very real ones when put to rigid test. But these difficulties do not mean that Edison has set the matter aside. Not at all; they await an opportunity of settlement, that is all. In the spring of 1915 a young Chicago inventor patented a device which goes far to fill this gap, but which needs yet further improvement to be practicable.

A large proportion of Edison's early films were industrial, for the inventor believes thoroughly in a proper understanding of commerce and industry. Some of the films in which he took the greatest pride were pictures showing factories in operation, where, from a piece of crude ore, the iron is made, the steel forged and fashioned into a steel rail for a railroad. Or, again, he likes a film where every detail is shown in the blowing of a glass electric light bulb. These films are in high demand. Many factories use them as part of the education of new employees.

This interest in commerce and things commercial has caused Edison to devote his inventive genius at various times to devices for helping the business man. Such was the electric pen, which consisted of a hollow wooden tube, the size and

shape of an ordinary penholder, fitted with a steel shaft. At the head of the shaft was a tiny motor, and the point was a steel needle. When attached to a battery by flexible wires, the needle point vibrated so rapidly that a continuous series of dots was made with the motions of ordinary writing. A stencil was thus made from which any number of copies could be run off. As a wag once said,

"It works like a man was writing with a wasp, holding the wasp's business end to the paper!"

The mimeograph, which, as now adopted for use on typewriters, is also to be seen in thousands of business houses; it is one of Edison's inventions. It has saved many hundreds of thousands of dollars in the issuance of circular letters.

Of the same character is the dictating machine, a development of the phonograph, which, with its 1914 improvement of the transophone, has already been described. These, however, are classed by Edison among his "lesser inventions," such as vocal engines, which will saw a hole through a board by the mere force of talking into them; typewriters, for the "Wizard" was one of the earliest to work on this invaluable asset to the commercial world; methods of preserving fruit; making of plate glass; details of iron manufacture; wire-drawing, and a host of other things.

Edison's connection with electric railroading should be mentioned. The first American electric locomotive was run in April 29, 1857, by Professor C. C. Page, of the Smithsonian Institute, the trip being taken over the tracks of the Washington and Baltimore Railroad. A speed of nineteen miles an hour was attained, the motive power being one hundred cells of Grove nitric-acid battery, each having a platinum plate eleven inches square. The cost, of course, was prohibitive, and while the trial trip succeeded, in a measure, the batteries were reduced to junk-heap material in the less than two hours that the trip consumed.

The first electric railroad in America, however, certainly the first regularly to carry passengers and freight, was Edison's at Menlo Park. In this railroad, which was about half a mile in extent, the current was furnished from the laboratory, passing into the rails, which were pitched high, and thoroughly insulated from the ground. The current entered one rail, passed up through the wheels of the locomotive — which themselves were insulated from the shaft — thence to the motor and out to the opposite rail through the other wheel.

Edison then made a contract with Henry Villard, of the Northern Pacific Railway. This was, that if the inventor could construct a railway at least

two and a half miles in length, equipped with two locomotives and three cars, one of these locomotives to be built for freight haulage and strength, the other for passenger service and speed, and the passenger locomotive could develop sixty miles an hour, then Villard would reimburse Edison for all cost of experiment, and would install the system on parts of his road in the wheat fields of the far Northwest. While the experiments were proceeding, Villard's fortune went to pieces in the Northern Pacific Railway crash.

Meantime Siemens and Halske, both of Germany, had built and equipped electric railroads of a high degree of efficiency, and Stephen D. Field, an American, had conceived the idea of the third rail. Both Siemens and Field attacked Edison's position, claiming infringements of their patents. Siemens' claim was set aside and Edison and Field joined forces, putting into operation an electric railway at the Chicago Railway Exposition. Edison was anxious to continue his work along this line, but so many other matters intervened that he was compelled to set that phase of experimentation aside.

This was no time for delays. All over the world, electrical engineers were working on the question of transportation. Van Depoele, a Belgian, and

Sprague, an ex-lieutenant of the United States Navy, were to the fore, and long before Edison had time to return to the fray, electric trolleys had become thoroughly established, and electric railroading was well in hand.

Although so many minds had been working on the transportation problem, especially with the storage battery, they had not been successful. Edison always believed — and now has proved — that the storage battery could be brought to a high point of efficiency. To F. R. Beach, at the time superintendent of the Street Railway Department of the General Electric Company, he once said, plaintively,

"I don't think Nature would be so unkind as to withhold the secret of a good storage battery, if a real earnest hunt for it was made. I'm going to hunt."

The hunt took six years. In 1906 the Edison storage battery had reached the point where less than one and one half per cent was imperfect. Yet two years of unceasing work followed before this small amount of imperfection was removed. Time and again statements were made that in the storage battery the "Wizard" was facing a fiasco. The temptation to deny the story was strong, the opportunity to tell what had already

been achieved was great. Still Edison stuck to his one invariable rule —

"Say nothing till you've got it right!"

The early storage batteries were successful, save for a small percentage, and thousands of orders came for more batteries. But Edison refused to sell. He felt that a percentage of imperfect batteries, no matter how small, would become cumulative, hurt his reputation, and cripple business in the perfect battery, when it should be completed.

The Edison storage battery, among all his inventions, is the least empirical. The stiffest hill to climb in the manufacture of a perfect battery was devising the "accumulator," that portion of the battery in which the "juice" is stored. The other difficulty was to get the battery down in weight.

Edison's manner of attacking the problem was thoroughly typical of all his methods. He began by getting hold of every type of storage cell that had ever been made or thought of, and analyzing the defects. He hoped that some device modifying one of these types could serve the purpose. None would. Every single one had a defect so fundamental that Edison came to the conclusion that it was not possible to work along this line. A new ideal had to be made.

The use of lead, largely because of its weight, was to be avoided. The exclusion of lead suggested the setting aside of the acid solution, using an alkaline electrolyte instead. Half a year of patient experimentation with every metal and nearly all metallic compounds known, gradually brought to light the fact that, from the point of view of the theory of the thing, iron and nickel were the metals desired.

This was the beginning. After over six thousand experiments — designed to find out the exact condition of activity of these metals when acted upon by the solution — the right processes were gradually evolved. The difficulty lay in the necessity for the development of the two metals to go on at exactly the same rate of speed. Finally, exactly the right solution of potash was worked out.

An Edison cell of the second period of development consists of steel plates containing oxide of iron and oxide of nickel, immersed in a solution of potash. With the charging of the battery, the iron oxide is reduced to metallic iron and the freed oxygen is absorbed by the nickel oxide. When the battery is discharged, the oxygen absorbed by the nickel passes through the liquid to the metallic iron and oxidizes it back to its original state.

In the words of F. A. Jones, "the oxygen burns the iron, but instead of getting heat, we get electricity as a substitute. It is a species of internal combustion in which the oxygen is stored up in the nickel to burn the iron. There is no other reaction. The simple metallic elements are iron, nickel and steel."

Edison has gone on perfecting his storage battery, and his inventions on it are numerous. Most of them, however, are along his accustomed line of making the invention commercially practicable. The storage battery problem was solved scientifically in 1903. Commercially it is not yet entirely solved. Thus in 1908, a special machine was invented by Edison to make tubes about the size of a lead pencil in which to pack the nickel.

Still more recently the "nickel flake" was invented, and the process is so ingenious that it may well be told. It is obtained by electroplating upon a metallic cylinder alternate layers of copper and nickel, one hundred layers of each. After this is done, the combined sheet is stripped from the cylinder, being then only about the thickness of the edge of a visiting card. It is cut in squares one sixteenth of an inch in size, and then dropped in a bath which dissolves away the copper but leaves the nickel unaffected, so that the plates or flakes of nickel float apart. When dried, these

flakes of heavy metal are so extraordinarily thin that they will float in the air like the feathered down that comes from a dandelion.

The accumulator, that bugbear of the storage battery in practical usefulness, was made simple and effective by Edison's discovery of the value of cobalt as the material for the condenser. Cobalt, however, had been found only in small quantities. To Edison's mind this meant nothing. Either cobalt could not be found in large quantities, in which case it was useless for him to experiment further with it, for it could not be made commercially profitable, or — it could be found. In the latter case, found it had to be!

In the same way that the inventor had sent men all over the world to find the bamboo which could be used for the carbon filament of the electric light, in the same way that he had set a horde of chemists at work testing wax for the phonograph cylinder, so to every corner of America did Edison distribute prospectors for cobalt. His determination and his perseverance were fully rewarded. A rich vein of cobalt was discovered on the North Carolina border, running across the mountains into Tennessee.

With the cell problem solved, and the accumulator material in hand, there remained only

the manufacture of the cells in such a way that they could be depended upon successfully to resist whatever demand would be made upon them by commercial use. For a year and more, Edison storage batteries were put on automobiles under conditions which, in many instances, reduced the machines to little more than scrap iron. Just one of these tests, for example, was sending out six machines, all of different designs and weights, to travel one hundred miles a day for fifty successive days over the worst roads that could be found. As one of the inspecting engineers said:

"The worst possible roads were chosen, and when a machine struck a track which was particularly heavy and bad, that track was covered to and fro all day until the hundred miles was accomplished. At the end of the fifty days the machines were little better than wrecks. Many sets of tires were worn out, axles split, and screws wrenched from their sockets, but when we came to examine the batteries we found that in no single instance had the slightest injury been received. The automobiles were fit only for the scrap heap, but the batteries were in perfect condition for another five-thousand-mile trip."

First, last, and all the time, Edison is an electrician. While he does not indulge in any dreams

of electricity as heralding the millennium, he does believe that it is its mission to make the world better. Speaking of his storage battery, he pointed out that it would gradually mean the exile of all horses from cities, and with the horses would go the flies, and with the flies would be banished a host of diseases.

A boy, a keen, intelligent boy about fourteen years of age, once was accompanying his father through the works at Orange, listening with extraordinary interest to the explanations that were being given by Edison to the elders of the party. When the visitors were ready to go, the "Wizard" — whose kindliness is as remarkable as his ingenuity — turned to the lad and said,

"What do you think about it all, son?"

"Well, Mr. Edison," the boy replied, looking at him with admiration, "I think you're an electrical machine yourself."

The inventor looked at the lad quizzically, pulling his right eyebrow in the way with which all his friends are familiar, and which usually means that he is thinking over a problem. Then, with a bright smile, he turned and said,

"From all we seem to know about what life is — maybe that's so."

CHAPTER XII

Master of Men and Patriot

In the winter of 1914, the Orange laboratories, from which had come so many wonderful inventions, burned to the ground. In them was much of the result of Edison's life work, thousands of unfinished plans, and scientific annotations for the future. From his home at Llewelyn Park, Edison saw the blaze and came down the long garden walk to the laboratories.

One of his associates, a man in whom Edison put his trust and whom he cared for greatly, seeing his chief standing there, came forward, and in the matter of fact tone with which he would have spoken in the machine-shop, said,

"What next, Mr. Edison?"

"I'm thinking," the master replied, "just how I'll rebuild."

Two days later, when raking through the ashes, it chanced that a photograph of Edison, with the edges charred, was found, but the strong, kindly face was looking out uninjured.

One of the employees, seeing the "old man" — as he is always called in the works — standing near by, came forward and held it out to Edison.

"We found this, sir," he said.

Edison looked at it a moment and smiled, one of his long slow smiles. Then, taking a stub of a carpenter's pencil from his pocket, he wrote — between the charred edges and the outline of the head — the words,

"Never touched me!"

Was ever a more American phrasing of indomitable purpose!

There is no such word as "disaster" in Edison's vocabulary. There is not even the word "failure." One is inevitably reminded of his swift retort to a young assistant who had grown weary of perpetual experiments, thousands of them, which had all alike failed to reach the desired end.

"It's a shame," said this young fellow, petulantly, "that we should have worked all these weeks without getting any results!"

"Results!" cried Edison, in surprise, "No results? Why, man, I have gotten a lot of results! I know several thousand things that won't work."

Difficulties of every sort have been thick in Edison's path. They appear to make very little

difference. He regards an obstacle in the way of accomplishment very much as he does a "bug," or awkward difficulty, in the working of a piece of machinery.

The story of the impudent office boy is a good example of this.

Many and many a year ago, when the electric light bulb had been invented and was first being made, one of the principal difficulties the inventor faced was that of reducing the cost. Gradually he was getting it down to a commercial basis when his plans were checked by a combination of some of the workmen in the shop. He has himself told what happened.

"One of the incidents," Edison has said, "which led to a very great cheapening, resulted from a little dispute I had. When we started making the bulbs, one of the important processes had to be done by experts. This was the sealing on of the part carrying the filament into the globe, which was rather a delicate operation in those days, and required several months of training before any one could seal in a number of parts per day.

"When we got to the point where we employed eighty of these experts, they formed a sort of union, and knowing that it was impossible to

manufacture lamps without them, they became very insolent.

"The son of one of these experts was employed as an office boy, and when he was told to do anything, either he would not do it at all, or he would do it grudgingly, giving an impertinent reply. He was ordered to be discharged, and given two weeks' notice. The union notified us that unless the boy was taken back, the whole union would go out.

"I didn't propose to be bulldozed by eighty men who thought they had a strangle-hold on my process of manufacture, and I started in to see if it were not possible to do that operation by machinery. After feeling round for three days I got a clew to it. Getting men I could trust, I put them at work and made the preliminary machinery. It worked fairly well.

"I then made a second machine, and tried a few men who knew nothing about that sort of work on the machine — laborers and such. When I found that they could learn in half an hour how to work the machine successfully, I knew I was fixed all right. I then hurried and made thirty of the machines.

"Up in the top loft we stored those thirty machines, and the night before the office boy was

scheduled to go, we worked in the evening up there, putting in benches, making connections and getting everything ready. The next morning we told the office boy he was fired, gave him his pay, and ordered him to clear out of the place as fast as his legs would carry him. Then the union went out. It has been out ever since."

In the days of the ore-milling plant, some labor agitators managed to get in among the miners and sent a committee to Edison to formulate certain demands. Edison, who is always courteous, (except when on the rampage, which is seldom) heard them with exemplary patience until one of them incautiously used the word "demands."

"Demands, eh?" said the inventor. "Go on!"

The committee stated what they wanted and arbitrarily told Edison that he could have four days in which to decide.

"I'll do the deciding," he answered, "and I'll not need any four days about it, either. Go back to Edison [the village] and the reply will be there by the time you are."

He telegraphed to Superintendent Conly to shut the works down then and there, as the scale of wages was actually higher than elsewhere and the demand was unreasonable. Next morning the men came in a body and begged to be taken

back on the old footing. That was the last strike among Edison's employees.

It is not because of his discipline, however, but because of his loyalty to his men, that Edison secures his men's loyalty to him. A good example of this was his support of one of his electricians when the man in question made a misstatement before a Board of Inquiry.

On the board, as it chanced, were a couple of keen men who knew a good deal about electricity, and when the young fellow made an error, these two members of the Board tripped him up. He defended himself as best he could, and, to his great relief, Edison, who was present, came to his rescue. The Board waived further discussion because of Edison's authoritative support of his employee. No sooner, however, had the Board left the room than the inventor turned to the young electrician, who had been feeling good over his "victory," and said,

"Now, see here, you were wrong about that whole affair. I saw that at a glance."

"I was?" the other stammered, amazed. "Then why on earth, Mr. Edison, did you indorse me?"

"Because I wasn't going to let that crowd have the satisfaction of crowing over you if I could help it," was the reply.

Is it small wonder that his associates will stay faithful to the last gasp?

In his general handling of men, Edison has the same idea as the Irishman who declared,

"There's only two ways of putting a pig through a hole in a fence; you can coax him, or you can kick him through. It all depends on the pig. But one or the other works, every time."

Ninety-nine times out of every hundred, Edison believes in the "coaxing" mode of treatment. But he can be drastic at times, in action as well as in speech. Quite frequently, too, his rebukes have a thoroughly American twang; as, for example, when he dismissed an assistant who was loafing on the job with the remark,

"You'd better get out of this. You're too slow for real work. It would take you half an hour to creep out of the field of a microscope."

It is necessary that Edison should understand the handling of men, for in industries directly attributable to him, not less than quarter of a million men are employed, in the United States and abroad. The laboratory staff, as of old, is kept down to men whom Edison knows personally, almost intimately, and these men, to a greater extent than any one else in the world, know the inventor's inmost thoughts. In his laboratory

he is full of ease and geniality, with a quick humor of his own and an intense appreciation of a good story. He is also a home-loving man, having been twice married, and having a daughter and two sons.

When, in July, 1915, Edison was appointed as Chairman of the Board of Civilian Inventors, the appointment was felt to be a superb and fitting capstone to his career. At the age of sixty-seven years, he was incomparably the greatest American to whom the nation could turn for wisdom in peace or war.

If the previous history of Edison is any clew to his future activities, one may premise that now he has done more than invent something himself, he has given a stimulus which has made the United States itself an inventor. He has marshaled the power of sheer brain. For the first time in the history of mankind, he has made a nation realize that its chief military defense lies in intelligence, especially as expressed by science.

Cromwell said, "Trust in God and keep your powder dry."

Napoleon said, "God is on the side of the heaviest battalions."

Edison said, "If you know you're right, there's always a way to win."

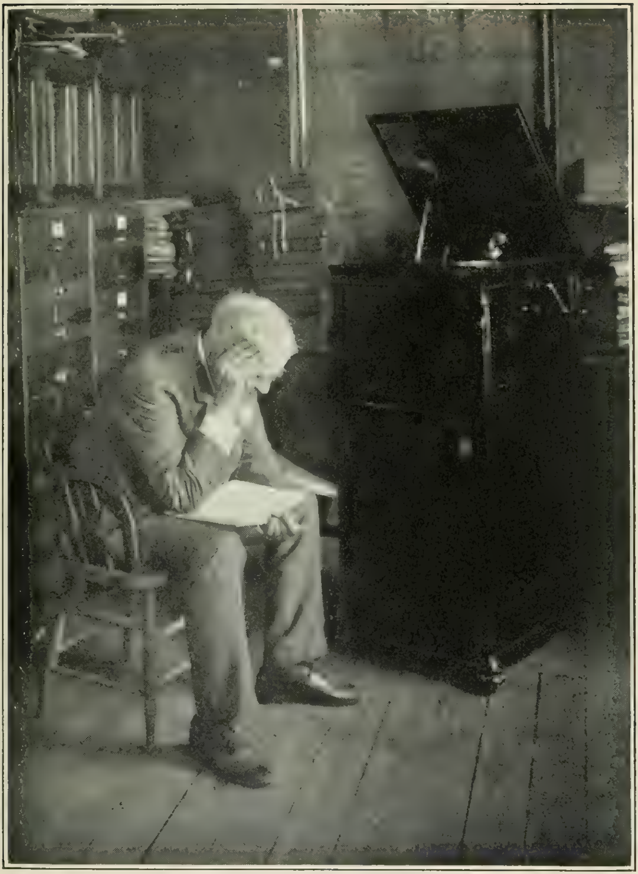
There is a certain historical perspective in these three sayings, which range from blind faith and brute courage to analysis and inventiveness. Cromwell's cry is a cry for courage, Napoleon's a cry for force, and Edison's a cry for judgment.

Now that this master mind of adaptive ingenuity is at the head of the Board which is designed to play its part in American affairs, it is timely to remember that Napoleon is peculiarly a favorite of Edison. When the great African explorer, Henry M. Stanley, called once at Menlo Park and spent the evening with Edison, the inventor showed him what was then his latest invention — the phonograph.

Stanley was fascinated with the instrument, but even his admiration for its value in recording the voices of the living could not keep him from unavailing regrets that ancient times had not known the phonograph, and so handed down, on imperishable cylinders, the voices of the great men and women who have made history.

Edison agreed, and Stanley, desirous of finding Edison's point of view on the past, said,

"Mr. Edison, suppose it were possible to obtain a phonographic record of one person's voice, some one person who had lived in the past, and no more, whom would you choose?"



THE KEEN-EARED "DEAF" INVENTOR.

Thomas A. Edison, in his phonograph workshop, listening to one of his new diamond-point machines.

The question was an entirely new one to the inventor. As Stanley recounts the occurrence, Edison closed his eyes, folded his hands across his knees and thought profoundly. There was silence for several minutes. Then Edison, opening his eyes again, said with an air of positive certainty in his tone,

"Napoleon!"

Both Stanley and Mrs. Stanley, who was present, protested. Stanley, with a natural liking for his own line of exploration, wanted to hear the famous world-challenging laugh of Sir Francis Drake, and Mrs. Stanley expressed a desire to hear blind Homer chanting the Iliad.

"No," Edison repeated, "Napoleon. It must have been a voice with a curious force behind it. A cylinder would be interesting."

In the discussion following, he showed a remarkable knowledge of the principles of Napoleonic military strategy, though at what time in his busy life he studied tactics is difficult to place.

It is significant that Sarah Bernhardt should have thought that in some ways Edison resembled Napoleon. In her "Memoirs," describing a visit of two days spent at the Edison household, she writes:

"I looked at this man of medium height, with a head slightly too large and a profile full of nobility,

and I thought of Napoleon I. There certainly is a strong physical resemblance between these two men, and I am sure that it is a case where the two brains would be found to be identical."

One may disagree with Mme. Sarah Bernhardt. Though perhaps one of the greatest tragediennes the world has ever seen, here she shows herself a little at fault in psychology. In one most important particular, Edison and Napoleon are at opposite poles. And, since Edison's appointment as Chairman of the Civilian Inventors, this point is all-important.

Napoleon was reckless of human life. Edison is extremely sensitive as to its value.

In Edison is none of the cold aloofness which is supposed to belong to the pure scientist, such, for example, as has given to Mme. Curie the title of "the little gray lady of stone." He himself is vibrant with life, and the human side of his inventions is always emphasized. He is a firm believer in the old proverb, "Life is larger than logic."

One of the most striking examples of this occurred when he was asked to assist the State of New York in experimentation for the purpose of establishing electrocution as a means for capital punishment. Edison refused, point blank.

The governor of New York had appointed a

special commission to investigate the whole question, and the chairman of this commission had a long conference with the inventor. Finally, Edison acceded to his requests that some experiments might be made at Menlo Park, but he made some sweeping stipulations. He would only agree that his works might be used on the condition that the experiments were devoted to finding out the place and the method of applying the electrodes with the smallest amount of pain. A phrase in one of Edison's letters has often been quoted. Speaking of this question of electrocution, he said,

"I should be sorry to see electricity put to so bad a use."

After a long series of experiments made at other places besides Menlo Park, and after a long fight in the courts, the State of New York finally adopted electrocution as the mode of execution. When the date for the first execution was set, and twenty-one scientists were invited to the momentous occasion, Edison alone was absent. In his letter to the Warden of Sing Sing, excusing himself from attendance, the great American inventor said, in memorable words,

"There are wonderful possibilities in each human soul, and I cannot endorse a method of punishment which destroys its usefulness."

In spite of this, Edison is no "peace-at-any-price" type of man. He has faced too many difficulties in his own life not to know that it is sometimes necessary to fight, and fight hard, to overcome obstacles. He has grimly faced apparent defeat for months at a time, only to wear down these enemies of refractory chemicals or machines that "simply wouldn't go," at the last to achieve victory in what had appeared to be a hopeless campaign.

In addition to this type of mind — the most valuable and the most American conceivable — Edison is well acquainted with the principles underlying war machinery. Explosives have always been a matter of particular interest to him. Ever since the day when, as a small boy, he blew out the front of a stove by trying to see what gun-cotton would do when put in a tin can and then placed in the fire, he has been interested in the sudden expansion of substances into gas — in other words, in explosions.

One of the few times when Edison ever was afraid of anything was when he was still a young telegraph operator in Detroit. He had been reading of the power of nitroglycerine and the ease with which it could be made. He and a companion made some. They experimented with

it, fortunately in tiny quantities, and were nearly blown out of the place.

Then, and only then, did it occur to Edison that he had enough nitroglycerine in that small room to blow up two or three city blocks. The explosive was put in a sarsaparilla bottle and tightly corked. Creeping out stealthily, under cover of night, the two telegraph operators — feeling like Guy Fawkes conspirators — went to the nearest sewer opening, where, first fastening a string to the neck of the bottle so that it could be lowered without any shock or concussion, they let it down into the sewer. Had it hit violently against the wall of the sewer, the whole section of the street would have gone up in the air and Edison with it. But, fortunately for Detroit, wherever that sarsaparilla bottle may be now, it hasn't exploded yet.

Even nitroglycerine, however, is a safe and comfortable companion compared to iodide of nitrogen, the explosive power of which is nearly four thousand feet a second. Besides this, Edison has made explosives still more powerful, and still more delicate to handle. Some of these are so unstable that if shouted at, the vibrations of the voice will "send them off" — and possibly the shouter will go off, too!

A story is told of the way in which Edison got rid of a party of ministers who — in the early days — visited his laboratory. They wouldn't go away. Hints were of no use. The parsons hadn't anything special to do and they stayed and stayed until Edison was nearly wild. After his patience was exhausted, an idea occurred to him.

"Taking some of the material he had been experimenting with," says F. A. Jones, "he put a drop or two about the room — in places where there was no danger of a minister being blown through a window. The visitors watched him with growing interest, apparently felt no uneasiness at his actions, but rather crowded round him the more.

"Then the inventor took a seat at the bench and continued his investigations. Presently he jumped up with a dramatic 'I have it!' and knocked a heavy book off the table so that it fell with a crash to the floor.

"What followed was rather worse than Edison had intended. No windows were broken, but through the deafening explosion which occurred, a number of glass bottles were smashed, an electrical apparatus was put out of business, a table was overturned, and the ministers were frightened almost out of their wits. They put their hands

to their heads in evident fear of something worse, and then asked what had happened.

"Edison took the matter very coolly and explained that such explosions were constantly happening, though he was glad to say they hadn't killed any one since the fall. He hoped there would not be another bust-up that day, but you never could tell. The ministers declared it was all very interesting, but they guessed they'd better be going, and grabbing their hats, they hastily bade the inventor good-by and departed."

At least a score of explosive devices, entirely new, unknown to any nation in the world, exist in half-developed state in Edison's notebooks. He has not carried them forward to full practical usefulness, owing to his persistent belief that the main purpose of life is to create, not to destroy.

During the last twenty years, Edison has been besieged by requests from foreign governments, offering hints of great reward if he would turn his attention to the invention of devices for war. To each and all of these the inventor returned a polite, but a decided refusal.

In the spring of 1895, during one of the many crises of the Venezuelan dispute, there was an epidemic of suggestions as to various means for national defense. As Edison had worked with

W. Scott Sims some time before in the perfection of a submarine torpedo boat operated by electricity, there was a general feeling that he might lend his services. By indirect channels, the inventor was approached in the interests of the Navy Department. The exact result of the conference was never disclosed, but Edison continued his work on the perfecting of the phonograph — on which he was engaged at the time — and the Navy Department said nothing more.

The Sims-Edison dirigible submarine torpedo boat was the first of its kind. In this ingenious device, when the torpedo was fired from a land fort or from a battleship, it trailed after it a long electric cable. This was on a drum aboard the torpedo and the line was paid out as the craft proceeded, thus eliminating any dragging of weight through the water. The cable passed through a small hawse pipe at a slight angle to the stern, so that it should have a continuous metal contact.

Through this line and contact, all the operations of the torpedo could be controlled from the point of its original sending. It could be steered, it could be raised and lowered in the water, its speed could be regulated, and every detail carried out by the several wires in this small cable. The

principle was — and is still — susceptible of development into a deadly means of warfare. In this submarine, Edison's part was the long-distance transmission patent, not the actual machine of war. At the time Edison, in an interview, forecasted the great development of submarines and stated that the nation which paid the most attention to this form of defense was likely to secure control of the seas.

Another of the inventor's ideas, also partly prophetic but still entirely original, was the "flying torpedo boat." The main difference between Edison's flying torpedo boats and the modern war aeroplanes is, that the Edison craft were small and automatic, not needing an aviator. As he himself suggested, these "birds of destruction" could be sent up in flights of a hundred or more, and a flock of them could drop bombs with a time release on a hostile fleet or an invading army. When asked about the cost, he replied,

"Well, yes, they might cost a bit. But a flock of 'em couldn't cost as much as one human life."

On the question of the possible invasion of America, Edison, at the time of the Spanish-American War, was a thorough-paced optimist. When the opinions of military strategists were

quoted that it would be no great task to capture New York, he answered,

"It would be more difficult for a fleet of warships to enter New York Harbor than it would be for a dozen fishing boats to capture Gibraltar."

To Edison, characteristically, the value of a human life is almost solely the work-value of that life. He is not greatly concerned about it in any other regard. He has never troubled himself with philosophy or metaphysics. He has strong opinions, but they deal almost entirely with the way in which a man can best live to do a life's worth of work.

On the question of eating, Edison has clear ideas. He believes in constant changes of food and declares that nature craves variety. "People who eat nothing but rice think nothing but rice," he said once, a little unjustly. He has a poor opinion of "food faddists," but thinks that most persons eat too much, especially of meat.

He has been quite a heavy smoker, rarely averaging less than five to ten cigars a day, even now that he has "knocked off smoking," but he is a bitter foe to cigarettes. He declares the poison acrolein, which is found in some cigarette papers, "one of the most terrible drugs in its effect on the human body. I really believe it often

makes boys insane. The harm that such a deadly poison, when taken into the system, must inflict upon a growing lad is horrible to contemplate."

His own capacity for work and his ability to achieve, Edison assigns largely to his power of shaking off worry and to his knack of staying awake as long as he needs to, and going to sleep at a second's notice, if the time to sleep has come. He has also the rare gift of being wakened out of a sleep suddenly and not feeling "grouchy."

"When he would lie down to take an hour's sleep," wrote one of his assistants, in the old Newark days, "after working, perhaps, on something for a couple of days or more, and, for some important reason we had to wake him up, and nearly shake the life out of him in doing so [Edison is a profound and heavy sleeper], he never showed any irritability, but would merely tell us to 'go easy' and not 'knock all the stuffing out' of him."

In appearance, at the age of sixty-seven, Edison conveys his character. He looks like a beneficent conqueror. His forehead is high and his features sharp, though the face is round. His eyes, which are blue-gray, have a straight and often humorous glance. His physique is good, and he looks "fit." He dresses like most American business men, the tales of his disregard for appearances

being exaggerated. People who have met him in his laboratory, and who have commented on "chemical stains on his sleeves" show little knowledge of laboratories and less of working scientists. The art of dress is to fit the costume to the occupation, and Edison in his laboratory gives the sense of being well kept. Only the superficial observer, inclined to hero-worship, would find anything at which to cavil.

This foolish popular yarn of Edison's disregard for his personal appearance is of the same character as many of the tales of his absent-mindedness. Like all deep thinkers, he is apt to become immersed in thought. This, to people who rarely think, is hardly comprehensible. As a matter of actual fact, however, Edison's mind is agile, and he can pass from one subject to another — in his own range — with absolute ease.

It has been said that Edison gives the idea of a beneficent conqueror. In one of the best-poised and most understanding appreciations of the great American that has ever been made (appearing anonymously in the *American Magazine*), this side of Edison's character is brought out with great force. The tale is there told of the inventor's latest conquest, this time, again, a conquest for the benefit of the whole nation.

In Edison's various activities, especially in the making of phonograph records, he needs approximately a ton and a half of carbolic acid a day. Carbolic acid is a product of distilling coal tar at a certain given high temperature. Ten tons of carbolic acid a week is a large quantity, and anything occurring to cramp the securing of so much material means loss.

When the European War broke out, there were large supplies of carbolic acid on hand, all over the United States, the manufacturers and wholesalers who imported it from Europe being well stocked. As the war continued, however, this supply began to run short, and in the spring of 1915 Edison, among many others, faced a situation which meant curtailment of industry and consequent hardship for American workers.

"Let's make carbolic acid here, in the United States," suggested Edison to the big drug manufacturing houses.

"Can't be done," was the reply.

"Why can't it be done?" persisted Edison.

"American coal has never been used for it."

"Why not?"

"It doesn't yield to the same process as English coal."

"Have you tried?"

"Every way we know how."

"Why can't you get carbolic acid out of American coal?"

"We don't know."

"Why don't you know?" came the insistent question, and the manufacturers of 1915, like the shipyard carpenters of sixty years before, found themselves silenced.

Edison went back to his works.

"Look here, boys," he said, "I can't get hold of enough carbolic acid to run us more than a month. By that time we've got to find out how to make it here. I need it, for one thing, and there's dozens of other industries that need it, as well."

There followed one of the old orgies of work. For four days Edison was invisible to any one except his laboratory staff. He — and they — slept around the laboratory building when their eyes glued together for lack of sleep. In the four-day period, the inventor himself lay down but twice, once for five hours and once for seven.

On the morning of the fifth day the superintendent of one of the big mechanical divisions was called to the laboratory. Haggard and worn out, but triumphant, Edison put some plans into his hand.

"I'll give you just three weeks," he said, "to put up this plant, make all the machinery those plans call for, and install it in full running order."

"All right, Mr. Edison," was the reply.

The mechanician — he would not have been a superintendent under Edison unless he was that sort of a man — did not turn a hair, though the job looked almost impossible.

Before noon of that day, ground was broken for a new building. Men by scores were thrown into the work, laboring three shifts of eight hours a day. Edison and the superintendent of the job worked one shift a day — averaging about twenty hours.

On the seventeenth day the plant was open and in full blast. The product was found to be in every way as good as the English product. Once again the supposedly impossible had been achieved, and through the genius of Edison, the industries which were likely to be crippled may proceed unhindered. A few slight improvements in cheapening the price will retain this market for the United States forever.

It was about ten days after this victory that Edison was interviewed and gave utterance to his ideas on America's relation to the world, whether it be in times of war or in cycles of peace.

"There's the real war," he cried, tapping with his finger nail certain substances on the table, which were recognized as raw materials usually imported from Europe and for the lack of which American trade was suffering; "the only war in which humanity has anything permanent at stake. Get into Nature's intrenchments and make her give up! That's what we must do. We've been depending too much on other people to do it for us, too satisfied to be a nation of assemblers, putting together what we can pick up quickest and cheapest. Now the other people can't give us our material any more, and where are we?

"Substitutes, substitutes, we've got to find them. Countless — no end — my head is buzzing with them.

"It has been too easy for us to import our materials. This European War came along to put us to it and teach us to depend on ourselves. I'm learning how. I've been as bad as the rest of the American manufacturers — maybe not quite as bad, but bad enough. I'm learning, though, learning fast."

Seldom in the history of the world has there been a more stimulating call to arms than this great cry of Edison's. It is a cry to every boy and man in the United States. It is a summons

to a nobler and loftier ideal than has ever been worded before. It is a phrasing of an unparalleled opportunity for greatness. It is the beginning of an era when the rallying call to youth and to manhood is the welfare of the race, expressed in terms of usefulness, not of dream and fantasy. It is the new chivalry which establishes a new order of knighthood — the men who work to make life richer for their fellows.

And, at the head, blazoning the way to this newer glory, as he has blazoned the way to progress for fifty years and more, stands the great figure of the great American, calling aloud,

"Come on, boys! I'm learning, I'm learning fast!"

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